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HABITATION AND ENVIRONMENT*

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IT IS generally recognized that the list of primary human requirements, which traditionally includes only food, clothing, and shelter, should be extended to include also fuel, tools, and luxuries. This basic list of material wants therefore assumes, or should assume, high significance in any systematic attempt to analyze man's relation to his environment. Most of these basic requirements have been incorporated into the field of geography. Two of them, food and clothing, together with the natural factors of climate, soil, and relief, form the larger share of the subject matter now grouped under the broad title "human geography." Regionalism also abounds in accounts of the getting of food and clothing. Fuel, elaborated since the Industrial Revolution to include all sources of power, together with tools, now a complex array of machines for transportation and manufacture, are a part of the regular stock in trade of all economic and industrial geographers.

The sixth "want", luxuries, the word being used here to include the entire array of cultural goods, is today largely outside the province of the geographer. These so-called higher and more esthetic activities of man have been taken over by an army of specialists. Art, literature, and music have grown and multiplied, developing a thousand and one branches, each the jealous prerogative of highly skilled technicians as well as the playground of hordes of their amateur camp followers. As a result, the cultural ascent and progress of man is today perhaps the most completely analyzed of all activities. Its literature has swelled to flood proportions, as scholars have considered where, when, and under what environmental conditions these cultural activities have flourished. Today the culture experts are working in both directions from the known—delving into archeological records to interpret the past, and projecting their philosophical curves into the future. In the face of such an impressive array of specialists the geographer tends to surrender the field and to content himself with a few generalities concerning "civilization" and the environmental conditions under which it seems to thrive. Huntington's "Civilization and Climate" is an example of this type of approach. The obvious deduction that plenty may bring surplus, and sur-

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plus provide leisure for cultural attainment, seems to have received less attention than the unfavorable effects of abundance and the desirability of overcoming obstacles. From such considerations has arisen the standard generalization that in a poor environment people are backward because all their energy is required for mere existence. But if "luxuries" are interpreted to mean merely additional automobiles or more diamonds they obviously fall within the field of economic geography.

For reasons which are somewhat obscure, shelter, the third item in the basic list of human wants, has been neglected by geographers. Except in a few special instances, the house has been generally ignored. True, the achitect and the builder have their own literature, most of which is factual and mechanistic rather than interpretive. Certainly there have been but slight attempts to analyze the relation of habitation to the natural environment. This fact is the more surprising because shelter or habitation is so greatly influenced by the elements of earth and the forces of nature. Indeed, the late Jean Brunhes, one of the few geographers who seem to have evolved a philosophy of habitation, has said, "Of all the phenomena involved in the satisfaction of essential human needs, the habitation is to the highest degree geographical" *(1)*.

Habitation is absolutely fundamental to man's scheme of life. A houseless human being is virtually unknown. Only a few scattered and primitive tribes, such as the Bushmen of the Kalahari Desert and the Arunta natives of the Australian Centre, are free dwellers—living in the open with little or no attempt to erect even the rudiments of a shelter. Under missionary influence some of the Aruntas now live in rude houses, but I have seen these same natives start joyfully on a "walkabout" during which they revert easily to their old type of open bush-living. Broadly speaking, more than 99.9 per cent of the world's two billion people spend from eight to twenty-four hours of every day within some type of house and the urge to procure, equip, and maintain a habitation is universal.

Habitation in Geographical Literature

Geographical literature provides only a sketchy sampling of environmental adjustment in habitation, the best treatments being of those regions in which the means of existence are restricted and population is sparse. This is not entirely accidental, since in such a habitat any human accomplishment stands in pronounced contrast to the barrenness of nature, so that the cultural landscape is etched into doubly sharp relief. Thus, under nomadism in the great world deserts every feature, every individual item of life lies exposed in all its significance to the explorer, the geographer, or even the casual observer. Here flocks, herds, and houses require easy mobility. The nomad's tent or yurt, made of local materials—camel's hair, felt, wool, or skins—which provides shade from the intense midday sun and warmth during the chilled desert night, is thick enough to withstand piercing winds, is easily erected

and struck, simple in its inner mechanics, packable and portable. The tent is now a classic example, familiar to all.

At the other climatic extreme is the cleverly constructed ice-block igloo of the American Arctic with its small, compact dome, smoothly streamlined against blizzards, lined with skins, and warmed by body heat and small oil lamps. Locally adjusted to polar barrenness, it has attracted attention equal to that accorded the tent. Both these examples of shelter, highly functional and superb in their compromise with paucity of materials, have their recognized place in the literature of earth occupance. Stefansson *(2)* has done the pioneer work in bringing Arctic housing to the attention of Americans, and Ekblaw included habitation in his study of the Polar Eskimo of Thule *(3)*. In addition, a few geographers have paid hesitant tribute to the lightly constructed humid tropical house, noting its ability to shed rain and its use of palm, nipa or other local materials, and sometimes deprecating its somewhat lazy functionalism. These three main house types, all primitive, are practically the only ones which have achieved general recognition.

Granted that the nomad's tent, the igloo, and the thatched hut of the tropics are regarded as excellent adaptations to environment, what of the great areas of the earth where these types are not found? Within the middle latitudes, where the climate is less rigorous than in the polar regions and where materials multiply in quantity and increase in excellence, habitation generally becomes richer and more diverse, thus giving the geographer an unexcelled opportunity for analysis. North America, Europe and eastern Asia should be zones *par excellence* for such studies. What has been done?

Each of the three standard texts on North America now used in American and English universities has attempted to give a complete picture of the human and economic life on this continent. Their treatments include resources, food-getting, manufacture, power, commerce, cities, and often social beliefs and attitudes. The largest and most widely used of these texts recognizes the cleverness of the Eskimo in building himself the type of snow house just mentioned, and also describes the construction of a thatched hut in the West Indies. The chapter on the Cotton Belt has contrasting photographs of houses at two economic levels: a white-pillared Southern mansion and a sharecropper's cabin. So far as this book is concerned, the remainder of North America is houseless. Except for a few fragmentary references, the authors of the other two books have completely omitted habitations. All three say by inference, "The homes in which the people of America take so much pride, and on which they spend so much of their time, money, and thought have no geographical significance. They are essentially similar in Philadelphia and Phoenix, to say nothing of Minneapolis, Miami, and Mexico City."

Certain Europeans have included houses as essential features of human geography. In his admirable book, "Principles of Human Geography" *(4)*, Vidal de la Blache devoted one chapter to a survey of building materials, their

accessibility and degree of permanence. Vidal believed that "individual and regional differences will never be entirely obliterated," despite the infiltration of new ideas and the wider variety of materials made available through trade channels. He described the Russian *izba* as a creature of the environment and gave to Japan and Greece the distinction of affording "the most striking example of harmonious adjustment between buildings and environment" *(5)*. His treatment also included human establishments as to site, clustered settlements in farms and villages, and scattered settlements.

Bryan, an English geographer who published his "philosophical conception of human geography" under the title "Man's Adaptation of Nature," takes the position that shelter is "the motivating feature of the cultural landscape" *(6)*. He discusses the three functions of shelter as the need for living space, work space, and storage space; and suggests that the most accurate representation of an area is attained by mapping of house distribution.

"White Settlers in the Tropics," by Grenfell Price *(7)*, contains the usual time-worn phrases about the "disgraceful" housing in South Africa, the "wretched" housing in Queensland, the "unsanitary" native huts of Costa Rica. Price has considered what he terms "the scientific invasion of the tropics" from the point of view of developments in transport and in medical and sanitary science, and has given little attention to the fact that successful white settlement in the tropics is at least partly dependent upon adequate and comfortable housing. He offers no practical suggestions for the improvement of housing, but expresses the belief that air conditioning offers the greatest hope for the future.

After stating that "the physical environment in which man finds himself has a profound influence upon his home and his workshop," Pearson, in "Growth and Distribution of Population" *(8)*, leaves the character of this profound influence entirely to the imagination of the reader.

In the field of human geography, American authors have, almost without exception, ignored or overlooked habitation. In the most recent edition of his "Principles of Human Geography," Huntington lists as man's material needs food, clothing, shelter, tools, and means of transportation, and states that "civilization rises high only when all the material needs are satisfied" *(9)*. He then dismisses shelter with a few brief references to the movable homes of nomads, Eskimo housing, and building materials in the tropics.

The subject of shelter is all but ignored by Semple in her "Influences of Geographic Environment" *(10)*; by Huntington and Carlson in their "Geographic Basis of Society" *(11)*; by Peattie in his "Mountain Geography" *(12)*; by Bowman in "The Pioneer Fringe" *(13)*; by the various authors of "Pioneer Settlement" *(14)*; and by Parkins in "The South" *(15)*. A recent "Human Geography of the South," by Vance *(16)*, contains no discussion of human habitations or of current housing problems, which are probably as significant as the dietary deficiencies he treats in detail.

Studies of the cultural landscape also tend to evade the discussion of houses. In his "Morphology of Landscape," Sauer *(17)* begins promisingly by stating that "the cultural landscape is the geographic area in the final meaning. Its forms are all the works of man that characterize the landscape. Under this definition we are not concerned in geography with the energy, customs, or beliefs of man but with man's record upon the landscape." Surely, houses are records upon the landscape, but Sauer disposes of them in this one sentence: "Housing includes the types of structures man builds and their grouping, either dispersed as in many rural districts, or agglomerated into villages or cities in varying plans."

Geographical journals have in recent years published surprisingly few papers on house types and their distribution. Notable exceptions are Nash's, "The Houses of Rural Brazil *(18)*, Kniffen's culturogeographic study of "Louisiana House Types" *(19)* and Hoover's "House and Village Types in the Southwest as Conditioned by Aridity" *(20)*, which treats shelter from cliff dwellings through adobe block houses to their modern adaptations now found in the growing cities of the Southwest. Finley and Scott have analyzed quantitatively regional variations in dwelling types *(21)*. Between 1911 and 1935 there were no papers on house types in the *Annals* of the Association of American Geographers.

It is regrettable that the *National Geographic Magazine*, distinguished for its excellent photographs, includes neither analysis nor interpretation of the many house types illustrated.

Suggested Criteria for Analysis of Habitation

In analyzing the areal distribution of house types perhaps the first question should be: does the house harmonize with the environment? We recognize that when local materials are used, as in adobe dwellings in the Southwest, the house seems actually to grow out of the environment. One has a feeling of fitness, of appropriateness, in the pastel colored cottages with thatched roofs on the gently rolling plains of the southern Ukraine. The early sod houses of Nebraska, as well as the combination of sod and dugout frequently used in the Panhandle of Oklahoma, while not built for graceful living, at least grow out of and seem more in harmony with the environment than the common but rather shabby and nondescript frame buildings with roofs of galvanized iron. It may be observed in passing that whereas pioneer houses are usually conspicuous or even awkward features of the cultural landscape, this is often but a normal phase in the growth cycle which leads to the more harmonious landscape of a long settled region, the final mark of cultural maturity.

Specifically, houses should not only harmonize with the natural landscape, but should in many cases be adapted to the local physiography. An alert geographer should recognize the instances in which relief not only influences choice of location (which is outside the scope of this address) but

also the type of structures. An entire study could be written on the characteristics of mountain houses throughout the world, including the Alps, the Andes, the Caucasus, and certainly the Himalayas, where centuries of practice have led to the evolution of types appropriate to local conditions. The sturdy timbered houses with overhanging eaves which seem to belong in the Bavarian Alps would be quite out of place, for example, in Atlantic City. Details of construction are also modified by underlying material. In Helsingfors the basement may be excavated out of granite much as a dentist drills for a filling, while in New Orleans there may be no basement, the house resting on piling driven deep into the Mississippi alluvium. Similarly, recurrent earthquakes have a modifying effect on house types.

Climate, which is a great influence on man's occupations and mode of life, is also a habitation control. The first rude shelter may well have protected man from the weather, and the primary function of houses today is still protection from extremes of temperature as well as from rain, wind, and snow. In Marble Bar, a mining town in the Australian desert, people live underground to escape excessive heat; even more numerous are the examples of underground dwellings to escape cold. Variability in weather, which some geographers consider essential to progress, creates its own problems in housing. In Georgia, with its mild winters and hot summers, less attention is ordinarily given to heating than to cooling and adequate ventilation in summer. In Vermont, with its long, cold winters and short cool summers, man's chief concern is with heating, since outdoor temperatures may remain for weeks below zero. In modern America, air conditioning is undoubtedly the most efficient method of both heating and cooling; but unfortunately it is still rather restricted in use. This emphasis upon the heating (and overheating) of houses is, however, largely American. The belief that is is unhealthy to live in a house having central heat is shared by practically all Australians and New Zealanders, as well as by many English people. This belief has definitely influenced house types in the Antipodes.

Methods of heating often vary both with the climate and with the abundance or paucity of fuel. In the Ukrainian steppeland it is necessary to make one fire serve the dual purpose of cooking and warming the occupants of the house. Here the Russian peasants sometimes build a chimney which gives the appearance of a large counter, in one end of which is an open fireplace and a cooking oven. This horizontal chimney counter, warmed from the inside, provides a comfortable place to sleep in winter. In several agricultural villages along the Dnieper river I have visited cottages which had this interesting functional structure.

The type of available building materials is one of the more easily recognized environmental criteria of regional differences. The stone house of the mountain, the log hut of the coniferous forest, and the house of adobe or sun-dried clay in the desert are all familiar examples. There is room, however,

for much new research in making known certain of the less well known local materials, such as the reeds used for the walls of houses by the Ainu in Hokkaido, and the serpentine formerly used for buildings in Philadelphia. Ever since the first cave man, out on a plain, heaped up a pile of rocks to form a new stone-walled cave, the only type of shelter he knew, man has been busy at the endless and fascinating occupation of building with local materials.

Any analysis of house types should certainly include investigation of their various functional uses. One of the earliest functions of the house was undoubtedly defense: against human enemies, marauding animals, floods, and other dangers. The tree house, the stilt-dwelling, the stockade of timbers driven into the ground, and the impregnable rock fortress are all examples of structures built for defense. Certain features originally designed for defense are still observable in modern architecture, long after the need for them may have passed. The inaccessible roof and the barred and shuttered window of Moslem lands are other examples of this functional use: in this case, a defense of one's women from unwelcome outside eyes. The French dwelling, surrounded in town and country by a high wall, is another survival of the family defense idea.

Structure and size of the dwelling are often modified by another functional demand, storage space for property. Any accumulation of surplus food, seed, or the raw materials for clothing or the goods of commerce necessitates an expansion of the living quarters. Especially in earlier times, when man did not have a separate business establishment, his house often became a bulging warehouse, such as one may see in the old Hanseatic towns about the Baltic. Many American farmhouses formerly had commodious cellars and attics where great supplies of food and provisions were stored from one harvest to the next. Our changing economic and social structure, with increasing specialization in trades and professions together with a grocery store on every other corner, has eliminated the necessity for the storage of food in quantity, so that the cellar is now being turned into a playroom, and the attic eliminated entirely.

Many farmhouses in Europe show interesting combinations of human and animal use. The Basques in Spain build great stone houses in which the ground floor is frequently a barn for the domesticated animals, the living quarters of the family being on the second floor. The Kabyle of the North African Djurjura *(22)* share the ground floors of their dwellings with any or all of their livestock. Variations of these multiple-function houses are found in the Netherlands, where a portion of the floor space is given to cow stalls and to a small milk-room where cheese is made. The modern American does not generally sleep under the same roof with his animals, but he does often provide in the house a stall for the family automobile.

Among these suggested criteria for the study of house types, stage of

cultural development is of the highest significance. Habitations generally improve in decorative style and in esthetic appeal as man increases his techniques and skills. We normally expect to see each advance in human ability mirrored in the architecture and the good taste of the home.

Culture transfer forms an entire field in itself. The migrant to a new land, accustomed to a well-loved type of cottage in the old home region, tends to duplicate it in the new environment. Many islands of distinctive habitations in America can be traced directly back to the land of their origin Clevinger has made a careful study of Appalachian mountaineers in Washington, and has shown how closely the Appalachian mountain house has been duplicated in parts of the Cascades *(23)*. Sometimes such transfers are out of harmony with the environment. A recent survey of Seattle has revealed many discordant types, including a somewhat stodgy Swedish farmhouse in an urban setting, some French provincial styles, and a number of misplaced adaptations of Mediterranean and Moorish houses. Nothing is more depressing than a Spanish house in the middle of Seattle, with dejected palms standing forlornly in the courtyard while the marine rains continue month after month. There is also under construction in Seattle a new residential suburb where all the houses are to be in the style of the restored buildings of Williamsburg, Virginia.

Thus far I have considered only sedentary dwellings but the modern world, as well as the desert, has its specialized occupations that demand mobility. In eastern Oregon the Basque sheepherder lives for months at a time in a wagon moved from place to place, and the Australian outback has its caravans or trailers serving both sheepmen and cattlemen. Thousands of Chinese families live their entire lives on junks, cooking on the back platform, sleeping on top of the cargo, moving back and forth on rivers and canals wherever freight is to be carried. Railways in America have their construction trains with bunk cars which follow the job. Many migratory agricultural workers are similarly equipped with trailers which they haul from one work location to the next. Certainly mobile living is one phase of the problem of shelter.

The criteria which have been suggested can give little more than a brief indication of some of the possibilities of research in habitation and its geographical background. Still more interesting are the many instances in which one, two, or three factors in varying proportions are involved, thus giving the geographer an opportunity to evaluate their relative importance.

Functionalism in Housing

In America the present watchword for housing seems to be functionalism *(24)*. For sheer efficiency in providing maximum shelter at minimum cost, the previously mentioned Eskimo snow-block house is probably supreme. Within a space so limited that it would seem impossible for the occupants to sleep and eat with any degree of decency or comfort, an Eskimo family, or

several families plus extra guests, can be sheltered, fed, and entertained. This is possible only by means of the most meticulous arrangement of belongings and a careful timing of use sequence. De Poncins, in his recent book "Kabloona" *(25)*, pays tribute to the orderly pattern of Arctic close living, where each member of the group with his individual belongings is systematized into the general scheme. Only in this way is it possible to dwell in such limited space without clash or friction. More significant, however, is the fact that this type of house in the frozen North costs little except the labor of the family, and so is available to the humblest and poorest member of society. Equality and self-respect in housing are available to all.

It is precisely in this latter category, self-respect, that housing in America often fails. We take it for granted that the poor can have neither quality nor equality. They live in slums, or are offered new housing at a cost far beyond their means. America, with its genius for functional gadgets, has solved most of the problems of heat, light, fuel, service, comfort, luxury, and entertainment; in short, almost all problems of everyday living except how to provide two or three-room respectability on a working man's salary. It is readily admitted that close living of the Arctic snowhouse type is not the answer. Oddly enough the Japanese have probably come closest to solving this knotty problem for society as a whole. Nothing else so far devised under middle latitude conditions gives so much living to poor families.

While they avoid absolute uniformity, all Japanese houses follow a recognized type which has apparently been evolved through many centuries of trial and error. Along with extreme simplicity in design and construction goes a general gracefulness in form and a feeling of appropriateness to the natural landscape. Economy in materials has been carried to a point unknown even to the thrifty Scotch. Framing is of cheap pine or fir, wall panels and window panes are made of paper, and straw matting on the floor with a minimum of wood underneath makes an inexpensive substitute for more costly rugs or carpets. Built with little or no glass, paint, plumbing fixtures, door knobs or other builder's hardware, the average Japanese house manages to achieve the same stark simplicity which we associate with pioneer cabins in the Kentucky Bluegrass. Inexpensive charcoal braziers take the place of stoves. The house has neither chimney, fireplace nor flue—another economy in construction. The Kentucky pioneer had far more furniture. And yet Japanese life is many centuries removed from pioneer conditions; we might better say that an old, well schooled and well disciplined society has gradually eliminated from its housing requirements all costly nonessentials.

It is in the functional sequence of room use, however, that the Japanese house reaches its highest efficiency. A system of living has been evolved by which the maximum use of space is achieved. Conventional thinking in America calls for many separate rooms—bedrooms for sleeping, dining rooms for eating, and other rooms for daily living and entertaining. In the conven-

tional Japanese house, where furniture and fixtures have been reduced to the lowest common denominator, it is possible to vary uses as needed, so that one room may serve for several purposes in rotation. Since man usually performs only one activity at a time, the thrifty Japanese may well ask: "Why possess three rooms, two of them continually idle while one only is in use? Why not play the drama of daily living on a single stage, shifting the scenery from human act to human act as needed?" Even the change in scenery may be simple. Accordingly, a single attractive living room with spotless floor mats of conventional design and size has practically no furniture, floor cushions being substituted for chairs. At the meal hour, trays which have been elaborated into miniature tables, light, practical, efficient, and set with individual food containers, are brought in and placed on the floor before each person. When the trays have been removed to the kitchen after the meal, the room is again a sitting room. At the retiring hour, when sleeping mats are drawn out of cupboards, laid on the floor and the bedding arranged, the sitting room becomes a sleeping room.

This sequence, the shifting of scene from function to function, avoids a heavy overhead cost of unused space, and an equally heavy investment in furniture and equipment, also unused by the householder during sixty to eighty per cent of his twenty-four hour day. In many Japanese houses, as in those of small craftsmen, the same room which is successively sleeping, dining, and living room may also become a workshop during ten or more hours of the day. In the larger dwellings sliding panel walls enable the owner to throw several small rooms into a large one, and thus to attain still greater flexibility in function at slight extra cost.

We cannot but admire Japanese ingenuity in achieving such a maximum of return from a minimum of space. Occidentals, without analyzing too carefully, claim that this system is enormously wasteful of human labor. On the other hand, the furnishings and other possessions of the average American home require hours of handling, care, arranging, and rearranging, in addition to the routine of cleaning and preparation of meals. Because of the easily removable panel walls, housecleaning is probably easier in Japan than in America. With all its mechanical devices, it is even possible that the American home with its multiplicity of rooms requires as much human labor as does the simpler Japanese house.

During its gradual evolution through the centuries, the house, at least in the main Japanese islands, has become a well-adjusted part of the culture pattern. In the pioneer north, in Hokkaido and Karafuto, the evolution of houses is still in progress. Even in the southern islands, the house with light walls which is so pleasant in the summer months and so admirably suited to the humid subtropics, calls for plenty of fortitude in winter. When North Japan was first settled some seventy years ago the pioneers attempted a compromise, erecting paper-walled and mat-floored houses but installing small stoves in

place of the customary charcoal braziers. The results, as might be supposed, were far from satisfactory. Walls have now been made thicker and paper windows have disappeared, but the Hokkaido house, with no chimney but with a flimsy length of stovepipe sticking through a window, is still a cultural and functional misfit. In Karafuto, which has a climate similar to that of Newfoundland, I have seen a few interesting adaptations by Japanese colonists of the Russian log house with a double entrance, but nowhere in the North have the rigors of the environment been met successfully. In their exterior appearance, there is none of the charm and appropriateness of Finnish forest huts or of Bavarian peasant cottages, both of which fit into their landscapes. It may possibly take a century or more to evolve a satisfactory house for the northern Japanese islands. In South Japan, however, a habitation is not only a house, but also a way of life, cleverly geared to simplicity, economy, and self-respect. In most instances it also possesses more beauty than is generally found in American habitations, even at higher economic levels. Without always recognizing the environmental adaptation, Taut, in his attractive book "Houses and People of Japan", has provided us with exhaustive details concerning Japanese housing *(26)*.

The Ecology of Habitation

Is there any reason why the ecological concept, so valuable in most of our geographical thinking, should not be applied to habitation? The most lively appreciation of this principle, however, has been found outside the field of geography. Perhaps Raynal best catches the spirit when he says: "It is bad enough when a house is out of focus with the scene, but when it is out of focus with the climate, with the social customs of the people, with history itself and common sense, the situation becomes uncomfortable "*(27)*. Speaking of new building in the South he then goes on to deplore the little New Hampshire house, which he describes as "lovely at home, embowered with elms and nestling into its native scene, but alien and incongruous in this landscape." The omnipresent bungalow, imported into America and now naturalized, he regards as really belonging "in Bengal where it could merge with the tall grass and be lost in the jungle. In a crowded development it looks like a fungus."

On the Pacific Coast there are the usual number of ordinary and matter-of-fact dwellings, but a few imaginative westerners and their architects are now planning and building homes in harmony with the natural background. Two suggestive examples, both in southern California, are a recently completed house by John Byers truthfully captioned as "Inspired by the Mohave Desert," and a rambling farmhouse by Edgar Bissantz, "Built to Fit the Foothills" *(28)*.

The geographer who is at all sensitive to the cultural landscape and to ecological fitness of things has plenty of opportunity to be, as Raynal says, "uncomfortable" when he begins to survey the world of houses. No particular region or locality has a monopoly on bad taste and inappropriateness. The un-

painted and grimy little boxes on stilts which climb the hills above West Virginia coal tipples can be matched by the equally drab corrugated iron houses common even in polite residential districts of Adelaide, the South Australia metropolis where eucalyptus, orange and lemon trees, olives and flowering almonds flourish in a Mediterranean setting. A similar regional maladjustment is observed in Hong Kong, where the unbending Englishman is prone to bring his town house of Birmingham brick, placing it high on the Peak, where not even the tender luxuriance of a tropical vegetation can soften its Victorian lines.

It is apparent that the ecology of habitation may well be included in human and regional geography and, in many instances, may even become the central idea for separate geographic studies. While in the past most of our classic examples have come from the Arctic or the tropics, it is quite unnecessary to range so far, since the richest fields lie today in the better known middle latitudes, which are replete with unused material. No geographer who has walked through the countryside in Lincolnshire or seen English thatched cottages in their native habitat, can have failed to be impressed with the "at-homeness" of these dwellings. In a different environment they would appear homesick and lost. Likewise, the thick-walled Moorish house with its patio, fountain, and framing of graceful palm and pepper trees, looking down on a blue sea in Spain, North Africa or Southern California, is as indigenous to the Mediterranean landscape as if it had sprung from the soil itself. Given time and good taste on the part of the builders, houses throughout the world tend to fit themselves naturally into the environment. That is perhaps only another way of saying that harmonious housing may become the rule rather than the exception.

It is true that we are at present beset by a wave of impatient functionalism which decries environment and suggests that the house, like the motor car, should become merely a standardized machine-for-living, turned off the belt *en masse* by factories, complete with all the newest free-wheeling and fluid-drive gadgets, ready to be set up anywhere, and later to be turned in on a new model. In addition there is the new nomadism of America awheel, hauling its compact little house on a trailer behind it, from job to job. In certain circles it is argued that we are about ready to abandon individual living and to take up our communal occupance in enormous barracks built like factories. In London and Chungking houses above ground are at present somewhat outmoded, and are being abandoned in favor of safer communal living in great underground burrows that permit the inhabitants to escape the bombs of a deadly machine age. It is a sad fact that the term "shelter" in its original protective sense is once more prominent in man's vocabulary.

All of these recent divergences from the accepted pattern, however, we firmly believe and hope are but temporary by-paths along the highway of habitation improvement. The individual house as a feature of normal human

geography has so far withstood every attack upon it throughout all history. Often destroyed or altered in form it always rises again to satisfy the needs of a family, almost always showing in its materials and structure the age-old relationship to climate, relief, vegetative covering, and historical background. And since shelter is so unmistakably related to environment we trust that the geographer in America will join his obvious interests to those of the architect and the planner in calling for a more harmonious and useful adjustment.

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LAND FORMS OF THE SAN GABRIEL MOUNTAINS, CALIFORNIA

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INTRODUCTION

THE TRANSVERSE mountain system of Southern California which begins at Point Arguello and extends 240 miles eastward is divided into four distinct ranges. From west to east the mountain ranges and the passes separating them are the Santa Inez Range, the Santa Clara River Pass, the Santa Susana Range, the Saugus-Newhall Pass, the San Gabriel Range, the Cajon Pass, and finally the San Bernardino Range on the east. The San Gabriel Mountain area, which lies 25 miles NE of Los Angeles, is the field of this study.

The Spanish settlers gave the name "Sierra Madre" to the range, but at some time later than the founding of the San Gabriel Mission on the San Gabriel River alluvial fan the mountain became known by the name of the Mission. The boundary of the area is considered to be the contact zone between the mass of igneous and metamorphic rocks that constitute the mountain mass and the many alluvial fans deposited at its base. This contact is sharp; the mountain face rises abruptly for four or five thousand feet above the surrounding fans, which in many places have coalesced into a piedmont plain *(1)*. In a few places where streams reach a local base level some recent alluvium has been deposited. Up to the present time no Tertiary or other stratified material has been found in the mountains.

In plan the mountains approach a trapezoid having an area of about 1200 square miles. The longer diagonal, from Newhall to Cajon Pass, is 60 miles; and the shorter, from Vincent to Pasadena, is 25 miles. The NW limb of the trapezoid is formed by Soledad Canyon and the Santa Clara River. The SW side is the Tujunga-La Canada fault valley. On the south side is the piedmont plain, stretching from Pasadena to San Bernardino. The San Andreas fault zone separates the San Gabriel Mountains from the Mojave Desert on the NE.

The purpose of this study is to apply the inductive method of research to the present-day landforms and trace their genetic development. Are the flat surfaces of the ranges remnants of old peneplains? What roles have inner structure, climate and vegetation played in modeling this mountain landscape? Did glaciation change the contours of the valleys?

PREVIOUS WORK

Most of the work on the San Gabriel Mountains done heretofore has been concerned with their tectonic history and structural geology. The most extensive work has been done on the western half of the range by William J. Miller and his associates at the University of California at Los Angeles *(2)*. The discovery of a large body of almost pure white anorthosite in the form of a batholith or large laccolith is particularly significant for the structure of the entire range.

In 1902, Hershey published a paper on the crystalline rocks of Los Angeles, Kern, Ventura, and San Bernardino Counties *(3)*. In 1905 Arnold and Strong examined a few of the crystalline rocks north of Pasadena *(4)*. Kew (1924) referred to the entire crystalline mass as a "basement complex" consisting of a metamorphic series intruded by granite *(5)*. Noble (1927) published a report of the work done on the San Andreas fault zone which bounds the NE side of the area *(6)*. Hill (1930) made a detailed study of the structure of the Little Tujunga Canyon area *(7)*. None of the above works has studied the valleys, landslides, nivation depressions or other surface features in detail. Furthermore, no comprehensive geologic study has been made of the Tertiary strata surrounding the San Gabriel Mountains. Until this work is completed, it appears difficult to arrive at conclusive opinions regarding the Tertiary history of the mountain mass itself. Due to this lack, the present paper attempts to analyze only the Quaternary developments, and to conjecture possible Tertiary conditions.

Geologic Base

The material which constitutes the San Gabriel mass is described by Miller as "a great block of pre-Cretaceous metamorphic and igneous rocks, thousands of feet high, bordered on all sides by Tertiary and Quaternary deposits." Further, to quote Miller: "The oldest set of rocks is made of schists, crystalline limestones, and quartzites of pre-Cretaceous age (probably pre-Cambrian)" *(2)*.

The largest single and mostly unbroken mass is the anorthosite, which lies along the northwest side of the range and extends about eighteen miles southeastward nearly to Strawberry Peak and Barley Flats. In Fig. 1 it is the area not covered by a grid of faults. Surrounding this batholithic mass of anorthosite is a narrow band of gneiss and schist which runs through Barley Flats and either stands upright or dips away from the anorthosite at a high angle.

Eastward and about at the center of the mountains is an almost completely shattered mass of diorite and granodiorite. The eastern end of this mass is caught in the grid of faulting formed by the secondary faults off the San Andreas fault zone and the W-E faults of the southern boundary which turn northward. Another mass of diorite is found along the southern boundary about Mt. Wilson and eastward to Little Dalton Canyon.

The San Gabriel formation, which extends along the entire SW and S border, is described by Miller as "mainly Placerita metasediments or Rubio metadiorite injected by much Echo granite and cut by later plutonics" *(2)*. This formation is the most faulted, shattered and crushed of all. Faults are numerous; only those which are of major topographic significance are shown on Fig. 1. The San Andreas fault zone, which trends NW-SE and is responsible for the depression of Cajon Pass that separates the San Gabriel from the San Bernardino Mountains, is best known. This fault continues south-

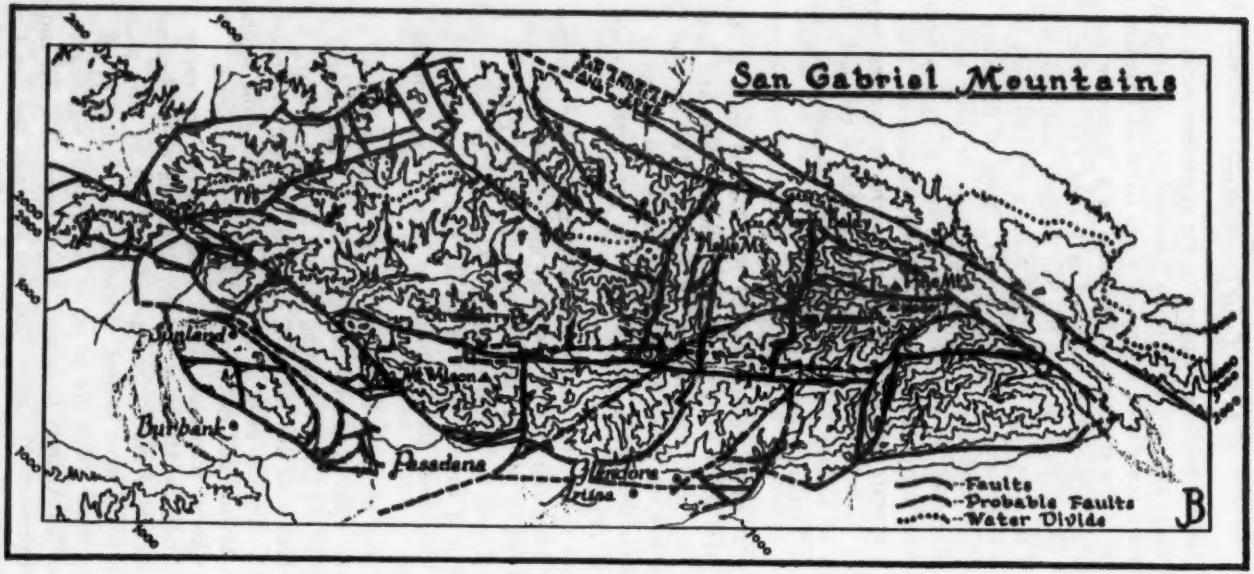

FIG. 1. Orientation map.

eastward to form the San Jacinto fault in the Peninsular Range. Parallel to it and twenty-five miles to the southwest is the Tujunga-La Canada zone which separates Verdugo Hills from the San Gabriel Range. This zone extends through the Puente Hills region and farther to the southeast becomes the Lake Elsinore fault. These two fault zones are connected by E-W trending faults which run along the N-NW and S side of the San Gabriel Mountains. This E-W faulting completes the blocking out of the range and gives it its long E-W trend, transverse to the normal direction (NW-SE) of the Coast Ranges of California.

The faults of Tujunga-La Canada are of high angle normal type. According to Noble *(6, p. 30)*, the San Andreas faulting has been at times of the high angle thrust type. "In general, the zone is a fault mosaic of elongated sliver-like blocks whose longer axes trend parallel with the strike of the main fault, but at many places the rock masses are so intricately shattered and different formations so mixed together, that it is impossible to map them or to determine their relations and age."

The age of the faulting on all sides of the San Gabriels has not yet been established, since on three sides thick deposits of gravel and sand obscure the Tertiary strata. However, some opinions have been expressed. M. L. Hill *(4, p. 161)* has assigned the principal faulting to "late Pliocene or post-Pliocene"; Arnold and Strong *(4, p. 188)* to "late Eocene or Oligocene," and Miller *(2d)* states that "important movements along these faults, involving uplifts of the San Gabriel region, date back at least to the middle Miocene," and that "probably movements along some or all of these faults went on intermittently throughout Tertiary time."

At whatever time the upward movements began, it is well established that they have continued through all Pleistocene and Recent time. Since the eastern half of the range stands nearly 5000 feet higher (Mt. San Antonio, 10,080 feet) than the western it appears that more movement has taken place in the east and northeast along the San Andreas fault than elsewhere.

The entire mountain range is deeply dissected by V-shaped valleys, many with sides so steep that they can be climbed only with the greatest difficulty. The pattern of faulting has determined the general stream pattern of the area. Streams follow the fault lines, excavating the broken rocks and depositing them on the alluvial fans surrounding the area.

The mass of anorthosite in the western San Gabriels, eighteen miles long and eight miles wide, provided the dynamic force which caused the uplift of the area. The series of schists and gneisses peripheral to and in contact with the mass gives way toward the east to less altered quartz and diorite porphyries. This is a normal relation of surrounding rocks to a batholithic structure. Furthermore, the orientation of the drainage basins of the region indicates that they are derived from a rising oblong massive structure. Their

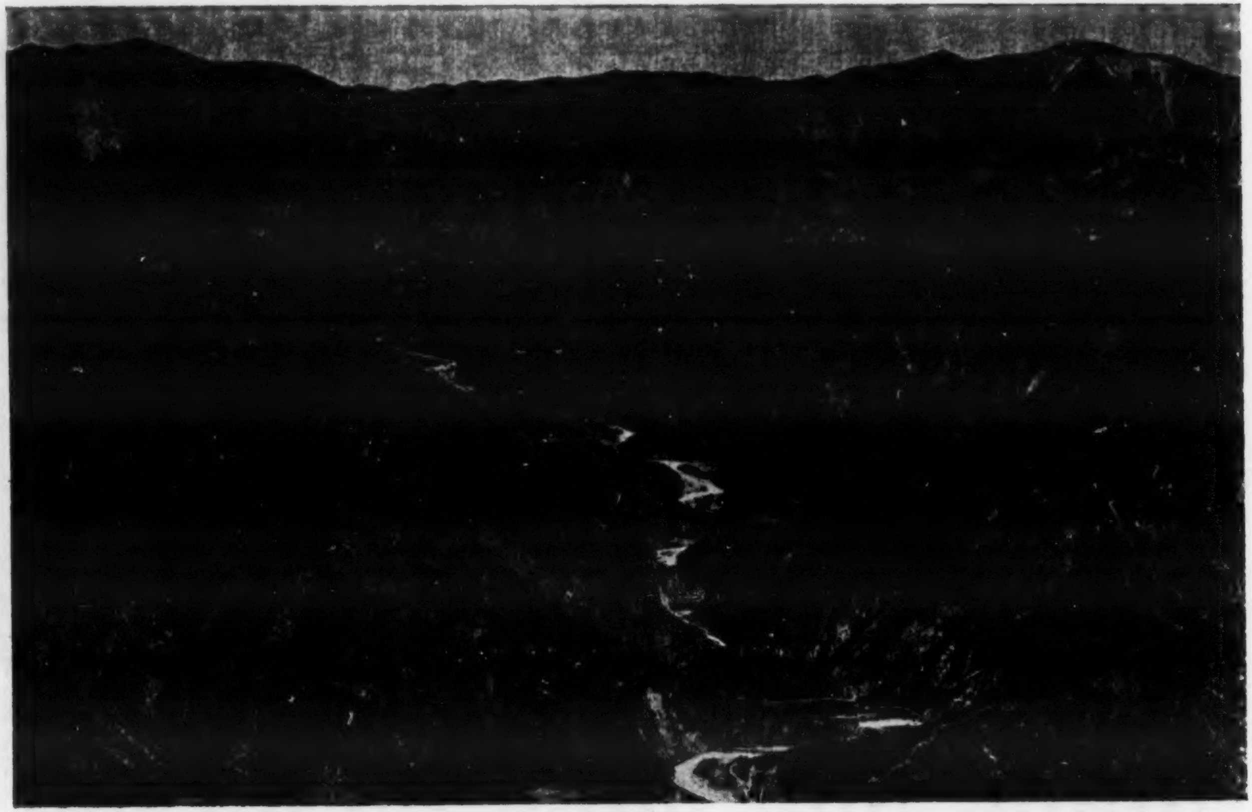

Fig. 2. San Gabriel Canyon.

outline shows no evidence of their having possessed any form other than that which is based on primary structure.

The present flats, valleys, and summit areas do not indicate a long Tertiary period of erosion and weathering at low levels. Especially, they do not point to a long period of rest and then rejuvenation or to the various cycles of erosion which have been postulated to explain the history of the region. If the San Gabriel Mountains were a surface approaching a peneplain at the end of Tertiary time, the streams would not conform to the structure of the underlying rock. They would have developed meanders on this flat surface and in later development would have left terraces along the valley sides when the uplift of 8000 to 10,000 feet took place in Quaternary time. Furthermore, if we accept peneplanation at a low level at the end of Tertiary time, how could glaciation have taken place in early Pleistocene time?

The land forms within the San Gabriel area seem to indicate steady continued uplift of the entire block during the Quaternary period. The intensity of this uplift was greater in the northeast along the San Andreas fault, than in the west along the Soledad fault. Well drillings in the Quaternary alluvium surrounding the area show the same texture throughout, and thus indicate erosion under constant conditions. The area was probably not high enough in early Pleistocene time to receive enough snow for glaciers to form. Faulting, nivation, landslides, and rock differentiation are the causes for the various so-called "flats."

Climate and Vegetation

Climate. Since the San Gabriel Mountains are almost uninhabited, few weather stations have been maintained within the region. The most important station is at Mt. Wilson on its southern border. The mountains form a boundary between the Mojave Desert and the mesothermal semi-arid climate of the Los Angeles basin.

After the bordering ranges are passed, the interior of the mountains has a *Csb* climate, in Köppen's notation. Snow is found from November to March in most of the elevations over 5000 feet. I have found drifts on the north side of Mt. San Antonio as late as July 15. The maximum period of precipitation is in the winter, but occasional thunder showers occur over the mountains in late spring and summer. Winter rains are often torrential, and send out great floods of water and coarse debris over the surrounding lowlands.

The discharge of the San Gabriel River has been measured at Azusa for the past twenty-two years; it gives some idea of the variability of precipitation in its drainage area. The total flow during a dry year has been as low as 9,600 acre feet, whereas in wet years it has been as high as 410,000 acre feet. During January, 1915, the monthly flow was 148,000 acre feet and that year the total discharge of the river was 279,000 acre feet. In 1903, the January flow was 1,500 acre feet and the yearly total 28,700 acre feet.

Fig. 3. San Gabriel River at Foothill Boulevard.

Mount Wilson, the section most representative of the climate of the San Gabriel region as a whole, has had an absolute maximum temperature of 100 degrees Fahrenheit in August and an absolute minimum of 10 degrees in January. Evidence of the heavy periodic rains is shown in the 26-year record of Mount Wilson. In December, 1921, precipitation totaled 29.4 inches. The normal for that month is 4.40 inches. During 1921 the total annual precipitation was 58.8 inches as compared to a minimum of 8.17 inches and an average annual total of 31.2 inches. In February, 1927, 17.07 inches fell, 50 per cent of the total for the year of 34.97 inches. Snowfall at the station is also irregular. The average is 51.5 inches, but during the winter of 1929-30 it totaled 104 inches. This irregular but heavy periodic precipitation is important as an erosional factor. The stream valleys which collect a great amount of coarse angular debris during the dry stages are suddenly thrown into flood and the material is piled behind restrictions in the valleys.

Snow often covers the entire range in winter and drifts in saddles and around peaks to a depth of 25 feet or more. These drifts are usually on the N or NE sides; their position indicates that the snow falls with south and southwest winds. The prevailing wind direction at the Mount Wilson station is SW. As spring comes, the change in temperature from day to night often oscillates between freezing and thawing; therefore the melting and freezing of the snow does a considerable work of nivation.

Since the range trends E-W, the southern slopes have much more intense insolation than the northern ones. Also, the runoff is excessive in such a rugged area. Hence little moisture is left for the vegetation. Chaparral and needle-leaved trees are distributed over the area according to exposure of slopes to the sun and the availability of subsurface moisture.

Vegetation. The vegetation of the San Gabriel Mountains is distributed as in all the transverse ranges of Southern California. At the base is the Sonoran zone, of chaparral. Above this is a transition zone of chaparral with islands of pine trees and grass where moisture is available near the surface. Finally, the highest zone of vegetation is dominated by the limber pine (*Pinus flexilis*).

No attempt is made here to give a complete account of the plants of the area. However, there appears to be a definite correlation between the ecological aspect of the vegetation and the character of the surface structure on which it stands. This sketch of the plant ecology will attempt to demonstrate that when a change in plant succession on a given surface feature takes place, that feature will, upon more intensive study, reveal a change in the edaphic elements involved in its development.

Much of the mountain area consists of steep-sided ridges and valleys, but in many places topographic features called "flats" are found. Structurally, these flats fall into three categories. First is the constricted valley which is filled with coarse rock debris behind the constriction. Very little soil is developed on this type of flat. The vegetation consists of pine trees

with practically no undergrowth and no grass, the species of pine varying with the altitude. This type of flat is only temporary, for as the stream smooths out its gradient the flat will be destroyed and the rocky debris moved down stream. The constriction is usually the result of cross-faulting or a landslide down the steep side of a canyon. Pine Flat, on the north fork of the San Gabriel River, is a good example of this type.

The second type is formed by faulting and landsliding, which results in a sag pond. Then erosion of the side walls raises the surface of the sag pond above the water level. A deep soil is formed with an underground water level near the surface. Reeds grow in the marshy area and the better-

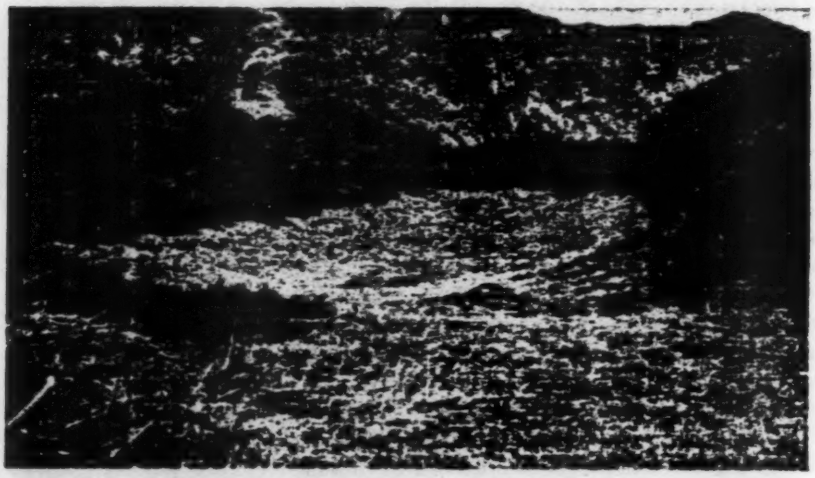

FIG. 4. Dry lake depression near the saddle of Sunset Peak. A landslide flat.

drained surface supports grass with occasional pine trees. Grass excludes the chaparral. The best example of such a flat is Brown's Flat. In this area Fern Canyon is undercutting the rim of the depression and will eventually tap the underground water supply and erode out the soil, and Brown's Flat will possibly return to chaparral.

The third type of flat is the ridge type, exemplified by Barley Flats. Here a banded gneiss and schist is turned on edge and the surface has crumbled through weathering. A good soil is developed and moisture is stored between the thin bands of schist. This moisture readily supports a cover of pine trees and grass. Dales start at the tops of the ridges and change to V-shaped canyons down-slope in the chaparral belt. Consequently, soil creeps into the V-shaped ravines and takes the grass vegetation with it. Fire can

destroy the chaparral and a grass cover may succeed it if the soil and moisture are available. However, on these ridge flats the grass appears to represent a second succession and to be expanding over an ever wider area *(8, pp. 76-82)*. Further, the dale appears to be growing at the expense of the ravine. Since this flat appears to be determined by the change in structure and in the outward spread of its vegetation and of the dale, it is distinctly a feature of the present landscape and not a remnant of a former erosional surface.

Valley Forms and Glaciation

The most characteristic feature of the San Gabriels is the deeply incised, steep-sided V-shaped valley (Fig. 2). In this respect the San Gabriel Mountains are in sharp contrast to the San Bernardino Range, which lies to the east across Cajon Pass and has extensive upland flats with rolling hills and lakes.

Of all the streams that rise in the mountains, the San Gabriel River system has the largest drainage area (Figs. 2, 3). It consists of five main branches, Cattle Creek, North Fork, Bear Creek, Devils Creek and West Fork. All of these branches are brought together in the San Gabriel fault zone and their waters are discharged through the main San Gabriel valley at Azusa. Since this system drains the area with the most distinct grid pattern of faulting, the various tributaries follow the direction of the faults with little evidence of stream capture.

The main San Gabriel River begins on the north slope of Pine Mountain at an elevation of 8500 feet. It flows northwesterly in a trough formed by one of the boundary faults of the San Andreas fault zone and is known here as Prairie Fork. Its descent is regular but sharp until it reaches the junction with Vincent Gulch at an elevation of 4500 feet. Here a fault from the southwest branches and strikes the San Andreas fault, making a large pyramid with three distinct triangular facets. From this point to Iron Fork the evidence of slickensides, fault gouge and rapids in the stream gradient reflects recent active movement. From Iron Fork downstream to Cattle Canyon and West Fork and out to Azusa the river has a very smooth gradient for such a rugged mountain area. It has been able to level out all obstructions that may have resulted from movement along the main San Gabriel fault.

The San Gabriel River follows a fault line from West Fork to Azusa. The gradient is regular but in plan the river makes extremely sharp and almost right-angled turns. These are not meanders formed by undercutting one bank and building a slip-off slope on the other. They are V-shaped canyons cut around the elongated obstructions in the valley. It appears that along such a main fault zone there are short right-angled breaks. Is this a characteristic of faulting and fracturing in massive igneous rocks? One of these valley obstructions is being used as the core in an earth-fill dam. The

Pine Canyon concrete-gravity type dam is a continuation of the same feature across the canyon. The steep V-shaped sides of the valley indicate that these bends in the plan of the river are not the result of the meandering of the stream on a peneplain and later intrenchment. No through-running terraces are present to indicate this. The bends are not arcs of circles or of logarithmic spirals *(9, p. 282)* that would indicate that they ever existed as meanders.

Through the western portion of the range, the water divide is at the crest of the batholith or laccolith of anorthosite. The drainage is of dendritic form and radial from the crest to Soledad Canyon on the northwest and to

FIG. 5. Rocks in the vicinity of Crystal Lake, derived from the collapse of pressure ridges of granodiorite.

Pacoima and Big Tujunga Canyons on the south side. Once the streams are out of the anorthosite, they follow the directions of faults and break through at cross faults to the surrounding piedmont fans. These streams show a very smooth gradient like the streams of the system of the San Gabriel River. Recent faulting has not changed their gradients. These valleys, like those of the eastern half of the range, have interlocking spurs, but no through-running rock or gravel terraces.

The transverse bedrock profiles of all these valleys show either a regular or a skew V-form. The valleys which run north-south show the regular steep-sided V-type, while those with a more east-west trend have profiles in the shape of a skewed V. On both sides of the water divide the short, steep sides of the skewed valleys face the water divide. In a few cases there are

valleys with a broad V-shape resulting from their following the direction of foliation of the schists and gneisses. When the water divides are drawn for all streams, whether main or tributary, they enclose elongated areas. The orientation of the individual drainage basins appears to me to be significant for understanding structure. A divide or a stream may shift its position, but it seems beyond the power of running water to shift the relative position of an entire drainage basin. Therefore, drainage-basin patterns must be the oldest land forms in an area. The drainage-basin patterns of the eastern San Gabriels show a definite orientation peripheral to the western structure. On

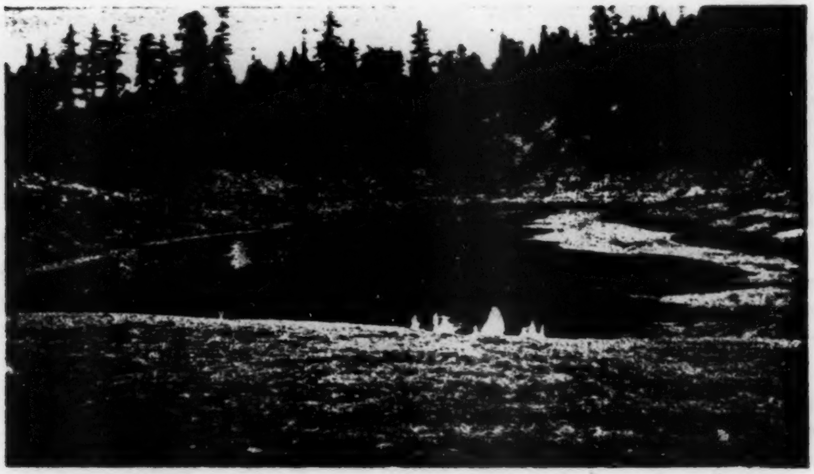

FIG. 6. Crystal Lake. On the left, rock slide. Part of the collapsed pressure ridge which forms the lake basin.

this basis, the eastern basins must have been arranged by the primary movement of a rounded batholithic type of western San Gabriel structure.

The water-divide profile, orientation of basins, and skewed valley patterns point toward the upward lifting of the entire block as "Grossfaltung" with only minor faults within the block, which are easily overwhelmed by the streams. This upward movement was probably accompanied by a slightly eastward drift of the batholithic structure. Noble and others through their studies of the San Andreas fault in the Cajon Pass have indicated this horizontal movement. An eastward drift of the batholith would account for the upheaval of Mt. San Antonio through reverse faulting.

GLACIATION

Miller *(2a)* has discussed the erosive action of ice in the San Gabriel Mountains in a paper published in 1926 and reaffirmed his conclusions in

1934 *(2d)*. He sees the possibility of glaciers descending on the south side of the range to an altitude of 2500 to 3500 feet and leaving large moraines at these levels. He makes no mention of the possibility of glaciers on the north side of the mountains, where the ice would appear most likely to collect on account of weak insolation.

The glaciation of the neighboring San Bernardino Mountain group has been discussed by Vaughan, who says:

> Well-preserved cirques and moraines constitute the evidence of the former period of ice action. This glaciation was of such a local character that the moraines do not extend far beyond the cirques and no typical glaciated valleys are found in the region. Practically all of the detritus is angular and no striated boulders were seen *(10, p. 335)*.

Further, regarding the San Bernardino group, Fairbanks and Carey stated:

> None of these glaciers appears to have descended much below 8500 feet and it will be seen from the descriptions given that the conditions had to be just right for their appearance at all. Such conditions were a northward or northwestward facing alcove which headed sufficiently close to the crest to receive the snows which drifted over the summit *(11)*.

In the light of these statements and of observations made on numerous trips through the San Bernardino group, it appears to me that ice accumulated only on the north side of the range and did not move far from its places of accumulation. Furthermore, the height of ice action in the San Bernardino Mountains is given at 8500 feet. These mountains are farther from the coast than the San Gabriels, and their highest peak is 11,485 ft., 1,480 feet higher than any mountain in the San Gabriel region.

The Pine Flat area has been cited by Miller *(2a, p. 75)* as the best example of glaciation in the San Gabriel Mountains. This flat is a debris-filled amphitheater formed by the grid of faults. Here the faults coming from the south are intersected by secondary faults which come from the NW off the San Andreas zone. This intense fault action is shown by the pressure ridges which run in a N-W and NW-SE direction through Pine Flat. The collapse of these ridges has left elongated moraine-like hills. However, upon close examination, these ridges are found definitely to be disintegrated bedrock, as is shown by the huge blocks of granite, only slightly displaced (Fig. 5). Had these blocks been moved any distance they would have shown striae.

The altitude of Crystal Lake (Fig. 6) is 5600 feet, and it lies at the base of a steep cliff far off to the west side of Pine Flat behind one of the ridges that run N-S along this entire side of the amphitheatre.

A large scar is visible on the cliff above the lake, which indicates that at one time there was a huge rockslide. This rockslide could easily have dammed the valley, which lies between the pressure ridge and the cliff, and formed this small lake. There is too much material in the ridge and it is too high to have been formed by ice which could have collected between the ridge and the cliff. The lake is elongated with the structural valley rather than with the valley coming from the cliff.

It is most difficult to attribute the shape of the contours of the Pine Flat amphitheatre to ice erosion because, had ice filled the entire area, the projecting spurs and ridges would surely have been removed. If we assume that Vaughan and Fairbanks and Carey are correct, that ice could only collect in the most favorable locations on the north side of the San Bernardino Mountains at elevations above 8500 feet, it is difficult to presume that it accumulated here at 5600 feet on the south side of the San Gabriel group. Furthermore, Pine Flat is not a cirque in the broadest definition of that term. With its location and the structure of the land surrounding it, Crystal

FIG. 7. An elongated nivation depression on the north side of Mt. San Antonio.

Lake cannot be a morainal lake. Many depressions such as the one containing Crystal Lake appear in other parts of the range and there is little doubt that their existence is traceable to the slumping and sliding of loose rock material.

Landslide and Nivation Depressions

Two types of depressions are found in the San Gabriel Mountain area. First, the landslide or slump type, and second, the nivation type found around Mt. San Antonio. Both types are minor landforms and only in the case of Brown's Flat is the feature noticeable on the topographic map of Cucamonga quadrangle.

Brown's Flat lies in the northwestern corner of the Cucamonga topographic sheet and is reached by a road from San Antonio Canyon. This flat was probably occupied at one time by a lake of considerable depth, but the

slump that produced the depression took place so long ago that the depression has been filled with material eroded from the slopes above it. Today grass and pine trees cover its floor. They form an island of this type of vegetation completely surrounded by scrub oak and chaparral. The slump apparently owes its occurrence to the undercutting of the southern and very steep slope of Fern Canyon, and to a fault which probably runs through the area. Since the slump is on the north slope of a front range, there was plenty of moisture for lubrication. The walls which surround Brown's Flat show no ravines such as appear on unslumped mountain ridges.

Fig. 8. Mt. San Antonio (Baldy), with nivation depressions near its crest.

Not far from Brown's Flat on the side of Sunset Peak is another, but much smaller depression, probably formed in much the same way (Fig. 4). I had the opportunity of studying one of these depressions only a few months after it was formed. In February, 1936, a landslide took place on the mountain slope just south of Glendora. The bedrock slipped out faster than the front top soil, and left a depression which contained an ephemeral lake during the wet season. Lubrication by water and the force of gravity on the heavier bedrock material caused it to slide out faster than the light top soil. This slide, which is about 500 feet across, formed a depression about ten feet deep which will gradually fill in from the slopes around above it. Similar slides were found in the San Bernardino mountains by Woodford and Harris *(12, p. 287)*.

The nivation type of depression is found at an altitude of 9500 feet on the north side of Mt. San Antonio. Here the snow lies in deep drifts eight or nine months of the year and does considerable work of weathering through the nivation process.

The depressions on the side of Mt. San Antonio are in places eight or more feet in depth and often excavated in bedrock (Figs. 7, 8). If the drift is elongated, the resulting ridge and depression are also elongated. The most active nivation is on the north side of the saddle east of Mt. San Antonio, where on account of the southeast winds the snow accumulates and makes deeper drifts than elsewhere. The deepest parts of these drifts are at some distance from the crest. Therefore, during the daily melting which occurs in the spring, the maximum amount of melt water is available in the center of the drift to do the work of solution and transportation. This fact explains why the depressions are down the slope some distance from the crest. The snow or ice is in no way responsible for movement of material; it is the melt water that carries away the particles of rock. The depressions are due to nivation and not to glaciation.

There are two conditions under which nivation depressions of this type will form. First, a relatively constant wind direction during snowfall is necessary, so that drifts will always form in the same place. Second, the snow must remain for most of or all the year and be in a region where there are many alternations between freezing and thawing. R. J. Russell has indicated that the kind of rock makes no difference whatever. In this particular locality, the bedrock is a highly altered porphyry, probably originally quartz-diorite porphyry. A micro-analysis of the rock shows the following: Microcrystalline ground mass, orthoclase and quartz; phenocrysts (over 2.5 mm. in diameter), orthoclase and plagioclase feldspar.

These have been replaced by the secondary minerals chlorite, epidote, sericite, calcite, and magnetite.

The nivation depressions have been made by solution of the bedrock by melt water. The work of solution is accomplished by the carbon dioxide in the melt water. Since the snow bank is porous, carbon dioxide (CO_2) will be present in the air, all through it. As the snow turns to melt water, this water will be at a low temperature, and will absorb the maximum amount of carbon dioxide. Therefore where calcium carbonate is present in rock overlain by snow the melt water will do the maximum amount of chemical weathering.

In this particular case calcite ($CaCO_3$) is the cementing element and is readily turned to calcium bicarbonate. This is highly soluble. In contradiction to Russell's statement concerning bedrock, one might say that where calcium

carbonate is present nivation depressions are more likely to occur than in non-calcareous rocks.

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THE LOCALIZATION OF THE AIRCRAFT INDUSTRY IN THE UNITED STATES

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THE AIRCRAFT INDUSTRY has always attracted attention far out of proportion to its physical or economic magnitude. With the growing importance of airplanes in transportation and in warfare, and the innately spectacular quality of aviation, the industry has occupied a place of high rank in the public consciousness, a position which has been tremendously furthered by the present emergency. This spotlighting of the industry has brought to light a very interesting concentration of factories in two small areas on opposite shores of the continent. The purpose of this paper is to outline very briefly the historical development of this remarkable pattern and to suggest a few factors influential in that development.

HISTORICAL DEVELOPMENT OF THE PATTERN

To facilitate the visualization of the changing pattern, a series of maps has been prepared, each of which illustrates, for a given year, the location of factories producing aircraft. The data from which these maps were constructed were yearly directories of manufacturers, published in trade periodicals. Number of wage-earners or production figures would in many respects be preferable for cartographic representation, but such data are not available outside the Census. The Census cannot be used because figures for many of the producing states are combined in order not to reveal data for a single plant. Thus location of plants alone is recorded on the maps, with no separation of important producers from minor manufacturers.

The map for 1925 shows the situation which prevailed after the expansion accompanying the first World War had subsided. Many of the plants shown were producing during the war period; others had been established since that time. The map indicates a strorg concentration of the industry in the northeastern part of the country, particularly in the environs of New York City. It will be noted that most of the plants are in relatively large industrial cities: Detroit, Buffalo, Dayton, Indianapolis, etc. The prairie states are entirely devoid of aircraft enterprises, and the Pacific Coast boasts only two small establishments.

By 1930 the picture has changed radically. A tremendous number of plants have sprung up throughout the country. The Middle West in particular shows a startling increase, with Wichita its capital. The Pacific Coast has also begun to rise, the Los Angeles area gathering in as many as eight factories, reaching a par with Wichita, Detroit, and New York, the other centers. Even the South and the Mountain States have a few. An interesting change to be noted is that it is no longer only the important industrial centers which possess aircraft factories. Several small towns through the midlands have a single plant each, and even Wichita cannot be termed a major industrial city. Many of the little

plants established during this period were never successful, and the drastic reduction in number and in volume of production in the succeeding years mirrors the unsound character of some of the endeavors and perhaps the overtaking of even some of the firmer ones by the general economic depression.

The total number of plants in 1935 is much lower than five years earlier. Only a few new locations are to be noted. The South has once more relapsed; New York has declined markedly, and Wichita's primacy has disappeared. Los Angeles alone of the greater centers remains apparently unaffected, although there has been an internal turnover there. By this time many of the organiza-

FIG. 1. Sites of plants manufacturing aircraft in the United States, 1925. Where there is not room enough for one symbol per plant, the symbol entered for the locality represents the number of plants indicated by the numeral placed next to the symbol.

tions for which Los Angeles is now famous are well established. This year, then, is in the period of retrenchment; the strong companies have remained, and several new ones have been solidly established. There are now scarcely a half-dozen important manufacturers who were not producing in 1935.

The picture for 1941 again embodies some striking changes. The number of factories has increased greatly, but the number of locations has not increased in anything approaching a like degree. Concentration is strong. By all accounts the most striking feature is the tremendous concentration about Los Angeles. Here is a true center of the aircraft industry. Perhaps the great number of plants is somewhat misleading, since some of the producers are of but minor importance. However, at least six of the largest factories in the

United States are located within the Los Angeles area, and several others there are not to be disposed of as insignificant. To the Los Angeles total might be added the two large plants at San Diego, bringing the figure for Southern California to a semi-total of 28 factories: over one-fourth of all those in the country. The second great concentration is to be found in the Middle Atlantic States, chiefly about metropolitan New York. Buffalo and the Detroit area also loom large, and Wichita has once more become the prairie-state leader. Another interesting development is the establishment of several factories in the South, two of which represent removals of plants from the North.

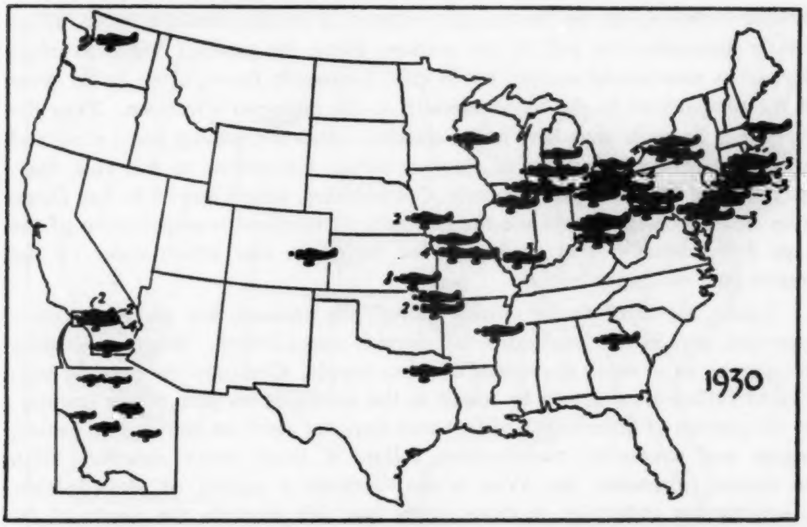

Fig. 2. Sites of plants manufacturing aircraft in the United States, 1930. Numerals have the same significance as in Figure 1.

Factors Effective in Producing the Pattern

It now remains to try to throw some light on the underlying factors, the product of whose interaction the pattern represents. A single rule cannot be laid down to account for all the locations. Thus perhaps the best that can be done is to examine the various factors upon which the localization of industries may usually depend, and try to determine, in a general way, their individual importance in the placement of aircraft factories.

First of these traditional factors is proximity to raw materials. The attraction of raw materials is felt most strongly if the materials are bulky, if they lose weight in the process of manufacture, and particularly if one material is required in large amounts compared to others. In aircraft manufac-

ture, the chief raw materials are metals: aluminum, steel, copper, and magnesium, along with rubber and various fabrics. These products reach the aircraft producer in manufactured form: as tubing, sheets, wire, cable, and many types of cast or stamped parts. Their variety is great, and in most cases the bulk is not large. Moreover, the sources of these manufactures are widely scattered. Their relatively low bulk means that transportation costs probably do not enter in as a very large percentage of the cost of aircraft manufacture. Certainly such concentrations as those at Los Angeles and Wichita are remote from the sources of materials.

A second traditional localizer is the market, although its effect is often difficult to determine. In the aircraft industry, a unique situation exists which greatly diminishes the pull of the market. Here, the product is not so often shipped by commercial carrier, but is most frequently flown, often by an agent of the company or by the buyer himself, to the customer's location. Thus delivery may be made anywhere in the country within a relatively short time, and without incurring high costs of transportation. Exceptions to this rule, may, of course, be found; as, for example, Consolidated, which moved to San Diego from Buffalo chiefly to obviate the necessity of overland transportation of the large flying boats it was producing for the navy, and which make up the greater part of its production.

Labor, the third factor usually called into account, has played a rather important part in the localization of aircraft manufacture. However, it does not seem to be so much a question of labor supply. Certainly the greatest supplies of skilled labor are to be found in the northeastern part of the country, yet the pattern of distribution of factories does not conform well to that factor. Engine and accessory manufacture follow it much more closely. With the recent expansion, the West Coast, without a supply of skilled labor in neighboring industries to draw from, has felt strongly the pinch of insufficient workers, and has been forced into an extensive program of training new workers from the bottom up. Perhaps more important than labor supply has been labor cost. The area that has benefited from this to the greatest degree is the Los Angeles area, where "open-shop" conditions and low cost of labor admittedly constituted one of the most important drawing cards for the aircraft manufacturer. Organization and wage increases are now wiping out this advantageous differential.

In addition to the three factors already discussed, two natural conditions, topography and climate, may be mentioned. The first-named one is probably of relatively minor importance except in special cases, since most cities have in their vicinity sufficiently large tracts of land to serve as airports from which the manufactured planes may be flown. However, those manufacturers who specialize in the production of flying boats do require sites offering sheltered bodies of water, ice-free the year-round. Climate, on the other hand,

looms quite large in the choice of locations. Every plane must be test-flown, and since planes take up room, it is important that they be test-flown and marketed as soon as possible. Thus a premium is placed on locations having good flying weather all year. A mild climate also lowers costs of construction and of heating. Southern California has benefited greatly through its excellence in this regard, and although the factor of climate has been one of the more important ones in the development of the industry there, it has not been a fatal deterrent to less-favored regions such as the Northeast and the Pacific Northwest.

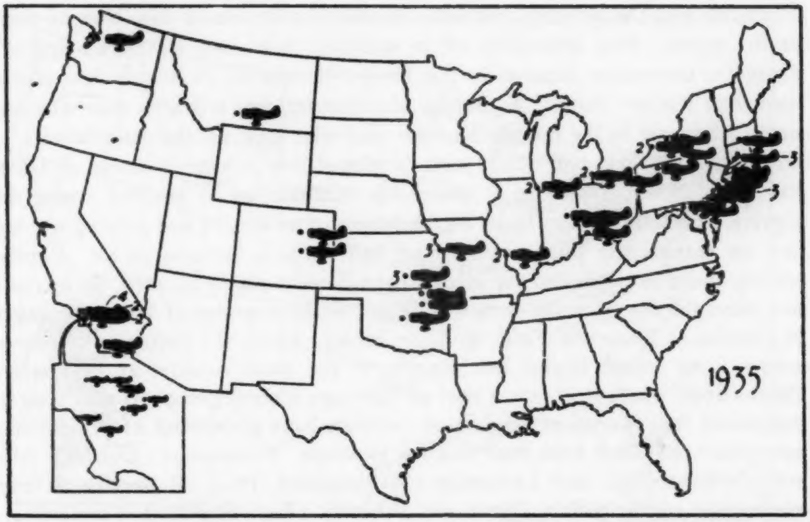

FIG. 3. Sites of plants manufacturing aircraft in the United States, 1935. Numericals have the same significance as in Figure 1.

The factors which have been discussed thus far are those which would be influential if the place of establishment were chosen after a careful survey of conditions the country over. It must be remembered, however, that the aircraft industry is a young one, one in which natural selection of locations has not had time to proceed to its utmost extent. If we had time to look at a large number of the locations and analyze the factors which brought the factories to them, we would find that none of the factors mentioned above, the traditional localizing factors, the factors which may now be observed to be in operation, can begin, either singly or in combination, to account for a very large percentage of the choices of site. Instead, here, as in many other phases of geographical interpretation of the present landscape, we must go farther back,

back to things which cannot be seen now, factors which are in no way self-evident. Instead of choosing a location carefully on the basis of best economy, the young designer often set up his shop in or near his own home town, in an empty factory or barn, obtained backing from local businessmen, and gradually expanded his local facilities as his business grew.

A very large number of the present situations may be traced back to just such beginnings. Donald Douglas lived in the Los Angeles area, obtained local backing, and set up his plant in 1923 in an abandoned movie studio in Santa Monica. When the business outgrew these quarters, a new factory was built, but in the same town. The Lockheed enterprise began in similar fashion. Northrop and Vultee were originally associated with one or the other of these earlier groups, later branching off to establish their own factories. Boeing's distinctly anomalous location in the Pacific Northwest at Seattle is a consequence of the fact that W. E. Boeing, the founder, was a Seattle man who had made a fortune in the lumber business and who took up the manufacture of aircraft as a hobby, one which soon developed into a huge business. Wichita has owed its importance to a remarkable combination of talented young designers, drawn to Wichita by its establishment of an airport and a flying service, and an enthusiastic businessman who had made a fortune in oil. Similar history could be recounted for many of the Eastern plants as well. To mention one example, the Sikorsky firm was organized by a group of friends engaged in aviation at Roosevelt Field, on Long Island. Later, the factory was moved across Long Island Sound, but remains in the same vicinity, at Bridgeport, Connecticut, where it is now a part of the huge United group. It may also be mentioned that several of the engine factories have grown out of pre-existing enterprises that have kept their original locations. Continental (Detroit), Allison (Indianapolis), and Lycoming (Williamsport, Pa.), all developed from automobile engine plants. Pratt and Whitney (East Hartford, Connecticut) grew out of a machine-tool industry there. It would be interesting and valuable to cite further examples from the beginnings of aviation firms, but limitations of space prohibit it. But the point may be definitely made that sheer historical chance, the juxtaposition of local engineering talent and available capital, has been one of the most outstanding, and probably the most significant factor localizing the industry. Carefully planned locations are more recent things; they have generally been chosen as localities to which to remove from a chance-dictated original site which has proved unsatisfactory. Newly-established firms may sometimes have profited by the experience of those who have shifted to a chosen location, choosing that situation for their own plants.

Under the processes operative in normal times, the Los Angeles area, favored by excellent climate, good labor market, an active Chamber of Commerce, and the nearness of markets provided by naval and army air bases, appeared to be developing into an "air-capital" comparable to Detroit's position

in the automobile industry. The eastern seaboard, near the "money capital," near the raw materials, near the labor supply, near a large market, and possessing harbor facilities for flying boats, provided the second region of strong concentration. It is, and always has been, the center for the manufacture of accessories. Other locations could be accounted for on the basis of historical chance, available capital, local interest, and outgrowth from or association with other industries.

Within the last two years, however, these normal processes of selection have been powerfully disturbed by a new force—location-planning for defense.

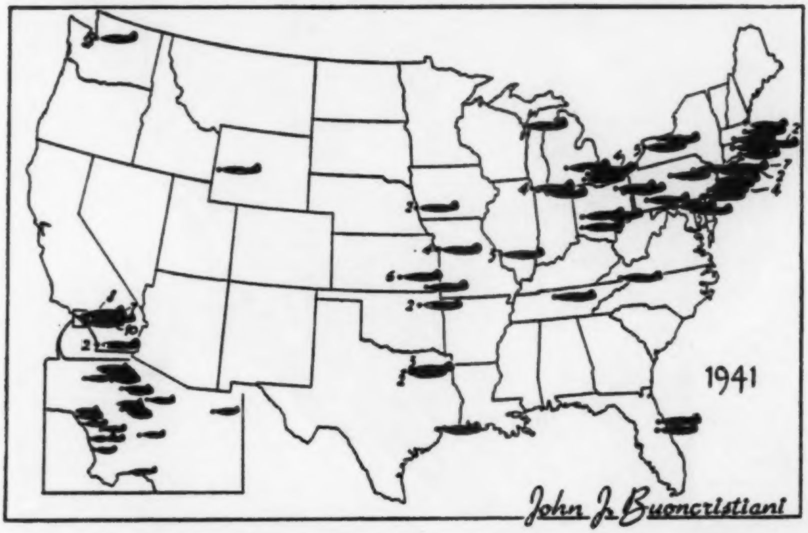

FIG. 4. Sites of plants manufacturing aircraft in the United States, 1941. Numericals have the same significance as in Figure 1.

The strong concentrations of the aircraft industry in the two coastal zones are felt to be extremely vulnerable to possible air attack. The Middle West is urged as the region in which new plants or branch factories should be erected. Although some argue that the supposed invulnerability of the Middle West is not as absolute as it is often pictured, it does seem that at least in the earlier stages of conflict the coastal areas would be more liable to attack. At any rate, even before the government took a hand in factory construction, aircraft manufacturers were beginning to shift toward the interior. But in the past year the government has taken an active part, constructing factories to be leased to the manufacturers. Among these are a plant for North American at Kansas City, one for Martin at Omaha, a Douglas branch at Tulsa, and a

factory for Consolidated at Dallas. Here, then, is location definitely planned. It is held by some that these interior locations will prove unprofitable after the passage of the emergency, but that proposition can be proved or disproved only by time. It may be felt that even after this period of strife has passed, considerations of continued defense will make the perpetuation of these factories desirable even to the point of moderate government subsidy. The fate of the interior plants may provide interesting data relative to the efficacy of the various localizing factors herein discussed. The economic value of a defense site makes itself felt only in wartime; such a site cannot necessarily hold its own under normal conditions of competition.

WIND AND TREES

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HORACE BYERS *(1)*, in his monograph on the summer sea fogs of the central California coast, calls attention to the fact that the Golden Gate-Carquinez Strait passage is the major gap through which summer maritime air moves into the Central Valley (Fig. 1). My observations reveal that the "air gap" is actually a zone of essentially low, rolling hill lands which extends nearly fifty miles northward from the entrance to San Francisco Bay. It is over much of

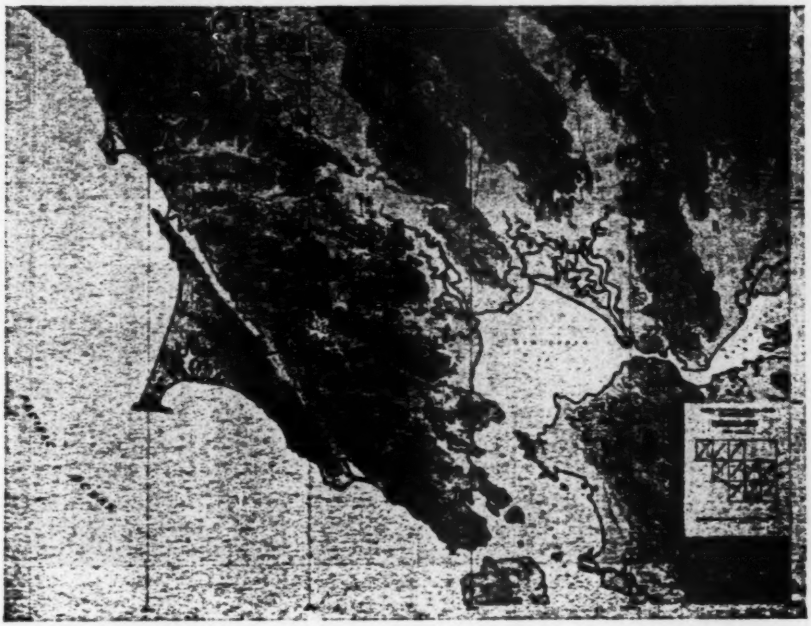

FIG. 1.

this central portion of the California Coast Ranges that the westerlies of summer are "funneled" in to replace the heated air of the inland valley.

A little more than a hundred years ago much of this area was rather heavily wooded. In the coastal area redwood, pine, and fir forests thrived, while inland the broadleaf associations of laurel and oak predominated. But with the white man came the ax and the practice of burning the cut-over lands. The result is that today much of the less precipitous area is an open grazing (dairy) country with only an occasional tree or small grove of trees to suggest the former vegetation. Through the destruction of these wooded lands man

has succeeded in removing nature's frictional brake which so efficiently retards surface winds. With the exception of the immediate coast, however, the prevailing winds are not sufficiently strong to create a dune hazard. On the other hand, these winds are persistent and forceful enough to affect the scattered tree forms in all but the most protected sites in an area of more than a thousand square miles.

Vegetation which has been affected by wind has long aroused interest. The reference here is not to the type of destruction which results from winds of high velocity, but rather to the type of non-lethal wind action which gives rise to dwarfed, distorted, or otherwise misshapen forms. Investigations and meas-

FIG. 2.

urements have been undertaken with the result that certain fundamental facts are now more or less generally accepted, the most tenable of which is the principle of the vertical velocity gradient first investigated by Åkerblom *(2)* and subsequently by Hellman *(3)* and others. Actually this principle involves more than the patent truth that wind velocities increase upward from the ground. Whether this increase can be expressed by a power law or a logarithmic law is a question that has been debated at length; current investigations *(4)* favor the conclusion that the vertical velocity increment is a logarithmic function of elevation when the temperature lapse rate is adiabatic.

In the mapping of the mean summer transport of air in the area under consideration I found such vegetational forms as are shown in Figures 2 to 5

to be infallible indices of the predominant direction of summer winds. Of the indigenous broadleaf tree forms encountered, laurels *(Umbellularia californica)* appear to be the most wind resistant, although low-lying, cushion-like scrub oaks *(Quercus dumosa)* compete with the laurels along some of the windier crests.

Figure 2 shows a small grove of laurels compactly sheltered in the wind shadow of a rock rampart. According to simple hydrodynamic principles *(5)*, any obstruction over and around which the wind may blow has a windward as well as a lee zone of minimum velocities. Measurements made by Geiger *(6)*,

Fig. 3.

however, reveal that the windward zone of calm is poorly developed in comparison with the one to leeward. As a consequence plants most frequently invade only the lee zone of calm wherever prevailing winds are either desiccating or mechanically destructive. In the event that this zone becomes filled by such wind-firm specimens as are shown in Figure 2, a new zone of calm forms to leeward of these, thereby permitting the vegetation to be extended downwind.

Figure 3 shows another group of laurels growing on the windswept crest of a hill near Tomales Bay. In exposed places, where rock barriers are wanting, laurels are windshorn into streamlined forms, the commonest of which is the "tear drop" form shown. It should be mentioned that under the most favorable growth conditions laurels range from 60 to 80 feet in height; the

windward outlier in Figure 3 grows in the form of a mat. It is principally through this quality of morphologic adaptability that the laurel is able to withstand the more destructive winds of gaps and summits.

Other species of trees also show the unmistakable effects of prevailing winds, but in a manner which differs somewhat from that described for the laurel. In the middle distance of Figure 4 is an evergreen oak *(Q. agrifolia)* whose bole grows erectly in the lee calm of a columnar rock outcrop. The asymmetry which develops aloft is conceivably due to the continuous destruc-

FIG. 4.

tion of sprouts on the windward side and the compensatory growth of others on the more sheltered side. Bernbeck *(7)* mentions that bending of the type shown in Figures 4 and 5 is possibly a product of perpetual burdening in excess of the limits of elasticity. Characteristic of many trees in the region, the relatively even base of the tree crown in Figure 4 is the combined result of arboreal grazing and back-scratching by cattle.

In Figure 5 a winter deciduous oak *(Q. californica)* shows that wind-shearing in this area is principally caused by the prevailing summer sea winds. The tree is situated a few feet below the summit on the leeward side of a small hill. The leveled-off crown is essentially a streamlined continuation of the windward slope and summit of the hill, and it is only in this portion of the crown that marked wind-firmness (compacting of branches and foliage) is well

developed. The procumbent bole, as in Figure 4, points in the direction of the prevailing wind.

Disregarding causal processes, it may be concluded from the foregoing that certain types of vegetation in regions of persistent winds may provide, among other things, reliable indices of prevailing wind direction. Although very unlike the streamlined forms in Figures 2 and 3, the form of the laurels shown in Figure 6 is also wind-induced; the reason it is not streamlined lies in the history of the human occupation of the area. In the few places where the laurel has not yet been destroyed by man the trees commonly grow in dense

FIG. 5.

groves or forests. Where these are subjected to steady winds only the trees along the windward margin are dwarfed; elsewhere only the tops of the trees are affected, i.e., become wind-firm. If, then, in the removal of a laurel forest a single tree or small group of trees escapes destruction it will, in all probability, lack the essential quality of wind-proofness. It is possible that exposure of such unadjusted trees to persistent winds would prove fatal to species incapable of making the necessary morphological adjustment. The exposed tufts of foliage which jut above the newly-forming, wind-resistant crown of the laurels in Figure 6 are unmistakably in process of dying. On the ground directly beneath the trees is an accumulation of the dead top branches which have already died and fallen. Ultimately, if it is permitted to develop naturally, this group

of laurels will become adjusted to its wind environment by reduction of height and attainment of compactness.

Although my opportunities for studying the radial growth of trees were limited, I examined a row of eucalyptus stumps which marked a former windbreak near Bodega, some cypress stumps on the shore of Bolinas Lagoon, and several hundred scattered laurel stumps in Gallinas Valley. Despite the prevalence and intensity of the wind the increment rings of both the eucalyptus and cypress trees were remarkably concentric. The growth rings of the laurel stumps were frequently complicated by the fact that nearly all were composite

FIG. 6.

and possessed, as a result, two or more growth centers. Perhaps it should be mentioned that the laurel, like many of California's chaparral species, is a capable "stump sprouter." As the sprouts grow in diameter they coalesce and produce buttressed or fluted trunks. However, in those specimens which had but a single growth center, there was no suggestion of eccentricity of growth rings. Finally, after an unfruitful examination of cross-sections, trunk and branches of a wind-stunted laurel which grew on the windward slopes of Black Mountain, I concluded that the prevailing wind direction is not reflected in the growth ring patterns of eucalypts, cypresses, or laurels in this region.

From the foregoing it may be said that although there is nothing original in the idea that most windshorn vegetation points the direction of the pre-

dominant wind, such vegetation provides useful knowledge in the fields of (1) climatic microanalysis, and (2), as is demonstrated by Figure 6, microclimatic change.

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A Geography of the Pacific Northwest

Otis W. Freeman and Howard H. Martin, *editors*: The Pacific Northwest. New York, John Wiley & Sons, Inc., 1942. xvi and 542 pages, maps; 142 illustrations. $4.00.

Several members of the Association of Pacific Coast Geographers have contributed to this comprehensive work on the northern States of the Pacific Coast region, and most of the rest of its membership will also find it of great interest. Besides the editors, both of whom are former presidents of the Association, the following members have participated in the preparation of the book: Warren D. Smith as a member of the publication committee, and J. B. Appleton, Phil E. Church, N. F. G. Davis, Frances M. Earle, Carl H. Mapes, W. B. Merriam, W. H. Pierson, H. F. Raup, H. H. Rhodes, W. A. Rockie as authors of chapters

There are six principal divisions of the book, which deal with the Indian life and history of the Northwest, its physical environment, natural resources, agriculture, industry, and population. It is illustrated by numerous maps and reproductions of photographs, and is accompanied by a large folding map of land forms of the Northwest drawn by Erwin Raisz. In addition to its usefulness as a guide to all who have occasion to study the geographic background of the region, the book is also a suitable text for courses in colleges and universities.

H. F. Raup.

THE ASSOCIATION OF PACIFIC COAST GEOGRAPHERS

Seventh Annual Meeting, Pasadena, California, June 18-19, 1941

THE SEVENTH annual meeting of the Association was held at the California Institute of Technology, Pasadena, California, on June 18 and 19, 1941, as a part of the program of the twenty-fifth annual meeting of the Pacific Division, American Association for the Advancement of Science, and associated societies. Four half-day sessions for the presentation of papers were held, besides the annual dinner session, at which the address of the retiring president was delivered and the announcement of the results of the election of officers for the year 1941-1942 was made.

Program, With Abstracts of Papers Presented

(Papers published in full in the foregoing pages are not abstracted here.)

Wednesday morning session, June 18:

Chorology and Conservation. A. W. KUCHLER, Claremont Colleges, Claremont, California.

Abstract: The landscape is a form of symbiosis. Every constituent of it has its effect on one or more of the other constituents. The disturbance of one therefore upsets the balance of the whole. Some tropical and polar regions show remarkable resistance to interference, but most landscapes are delicately balanced. Chorology revealed the symbiotic character of life in the landscape. Conservation preserves and reconstructs it. If a suffering landscape is to be restored to its previous healthy balance, the correction of one outstanding deficiency is inadequate. It is necessary first to know as exactly as possible just what conditions prevailed prior to the disturbance. Chorology makes this investigation and thus supplies the basis for constructive conservation. The results of chorologic research are blueprints for the conservationist.

Sites of Prehistoric Community Houses in the Chaco Canyon Region, New Mexico. MALCOLM BISSELL, University of Southern California, Los Angeles.

Abstract: The Chaco Canyon region in northwestern New Mexico is famous for its relics of an advanced prehistoric culture. These include the largest known community dwellings in North America, which date from the Great Pueblo period and were constructed approximately between 900 and 1100 A. D.

The region formed a natural and cultural unit extending about 25 miles from east to west, but with the main center of population along an eight-mile stretch of Chaco Canyon. A study of the sites chosen for the buildings shows a remarkable lack of consideration of the element of defense. Accessibility to building materials and proximity to water supply for domestic purposes were apparently also negligible factors. Climatic considerations seem to have played a part in the avoidance of the south side of the canyon. In practically all cases, however, the buildings were located where fields could readily be irrigated by flood waters, usually from tributaries of the main stream. Some evidence of prehistoric irrigation structures has been found.

These facts suggest that the climatic conditions in the Chaco Canyon region a thousand years ago were not greatly different from those that obtain today.

Roads and Transport in Colonial Mexico. ROBERT E. WEST, Office of the Coördinator of Information, Washington, D. C.

Abstract: In Mexico, during the 16th and 17th centuries, the conveyance of precious metals and tropical agricultural products to the port of Veracruz for export and the distribution of European imports to various parts of the country were a vital factor in Spanish colonial economy. To effect this transport, trails, which followed Indian trade routes, were extended outward in all directions from the Mesa Central. The road system consisted of (1) connections between the central plateau and the adjacent tropical lowlands, and (2) roads leading northward to the mining districts. Seven trails comprised the connections between highland and lowland: (*a*) the trail to the Huasteca (the area around the present Tampico); (*b*), the vital roads to the port of Veracruz; (*c*), the long trail southward to Oaxaca and Guatemala; (*d*), the road to Acapulco on the south-

western coast; (*e*), the Ario trail from Lake Pátzcuaro into the Balsas depression; (*f*), the Guadalajara-Colima trail; and (*g*), the road from Guadalajara to the west coast. The distribution of modern and projected routes is essentially the same as that of the routes of colonial days.

Three modes of transportation were employed: (1), the Aztec *tameme* system—i. e., human transport; (2), mule pack trains (*recuas*); and (3), two-wheeled carts pulled by mules. Carts were used principally in areas of level terrain (for example, on the roads of the northern plateau) and as a means of defense against Indian raids on the road; *tamemes* and *recuas* were employed mainly in mountainous country.

Havasu Canyon and the Havasupai Indians. J. W. Hoover, Tempe, Arizona.

Abstract: Havasu Canyon is a branch of the Grand Canyon of the Colorado River. Its peculiarities both as a natural feature and as the dwelling of the Havasupai Indians derive largely from the high concentration of calcium carbonate in solution in the stream that flows through it. This substance is precipitated out of the water of the stream along its course to form terraces of travertine. These deposits have trapped silt also carried by the stream, and have thus formed a flat valley floor with an area of about 500 acres. The deposition of travertine proceeds rapidly, even in irrigation ditches. The valley floor is subject both to overflow and to erosion by floods. The most destructive ones in the recent history of the valley occurred in 1909, 1928, and 1935.

The Havasupai, who inhabit the valley floor, number only about 200. The livelihood they obtain from their valley is meager, since they cultivate only about 80 acres of gardens.

Reclamation in the Zuider Zee. Howard H. Martin, University of Washington, Seattle.

Abstract: In the last twenty years the Dutch have embarked upon the drainage and reclamation of the larger part of the Zuider Zee. The estimated area of the land thus to be reclaimed is 867 square miles of cultivated land, which contribute roughly an addition of 10% to the arable area of the Netherlands.

The damming of the Zuider Zee was effected by constructing a massive, storm-resistant sea-wall from the northeastern tip of Wieringen Island to the coast of Friesland. Too large to be handled as a single drainage project, the reclaimed area is divided into four parts, the Northwest, Northeast, Southwest, and Southeast Polders. Pumping of water from the Northwest Polder began early in 1930. By January, 1931, most of the bottom of it was exposed. Powerful trenching machinery then began the dredging of ditches. A systematic soil analysis was made. On the lighter and sandier soils a cover crop of mixed grain was drilled immediately. In 1932, twenty per cent of the polder was sown, and year by year the acreage sown has been increased. Salt in the soil water is removed with the excess of water derived from precipitation and seepage. From five to ten years are required before sea bottom becomes really good pasture or grain land.

Preliminary farm operations in the new polder were carried out by workers employed by the government. The plan of settlement adopted gives each colonist 20 hectares of land. Prospective settlers were examined as to their fitness, and no land was sold to capitalists or speculators. Broad mounds or safety islands have been built as sites of villages. Building regulations have given the settlements an air of permanence. In comparison with older reclaimed areas the new polder has fewer barge canals and a denser net of highways.

Glacial Features and Glacier Recession in the Upper Lake Chelan Region, Washington. Otis W. Freeman, Eastern Washington College of Education, Cheney, Washington.

Abstract: Lake Chelan occupies a glacially eroded valley in the northern Cascades of Washington. It is 60 miles long and 1500 feet deep, its greatest depth being nearly 400 feet below sea level. The valley was excavated mainly in granite, and the glacier that once occupied it was over 4,000 feet thick. The deepest parts of the lake are near its head, where the glacier persisted longest. The main sources of the Lake Chelan Glacier were in Railroad, Agness, and Stehekin Valleys. The amount of deepening near Lucerne, at the south of Railroad Creek, is estimated at over 2000 feet. The evidence for this amount of deepening is that Domke Lake, in a preglacial course of the stream, is 1200 feet above the level of Lake Chelan near where the lake has a depth of 1200 feet.

The small remnants of the Chelan Glacier that still persist are all in the upper Lake Chelan region. The remnant ice fields are of the familiar type of cliff glaciers, lying on the steep upper slopes of their cirques. The glaciers are retreating rapidly. Measurements

of the retreat of Lyman Glacier between September, 1929, and September, 1940, showed a retreat of 58.5 feet per year. Its total recession since about 1900 is estimated at 1748 feet.

(The essential content of this paper has been published under the title "The Recession of Lyman Glacier, Washington," *Journal of Geology*, 49:764-771, 1941.)

Wednesday afternoon session, June 18:

Areal and Annual Variations of Climatic Types in California. Arch C. Gerlach, Los Angeles City College, Los Angeles, California.

Abstract: The climatic records of 150 stations for 25 years show that in general the area that experiences *Cs* climate (Köppen's notation) every year lies along the coast north of San Francisco and in the foothills of the northern Sierra. Desert climate occurs consistently in the southern part of the San Joaquin Valley and in the southern part of the State east of the Sierra and the Peninsular Range. Microthermal climate is experienced every year only on the higher slopes of the Sierra. Steppe climate occupies the rest of the state in the majority of years. Contractions and expansions of the areas of *Cs, BW,* and *Ds* climates from year to year leaves, however, only one station (Susanville, in northeastern California) with *BS* climate throughout the period of 25 years.

A comparison of maps showing the distribution of the basic climatic types during the periods 1916-1926 and 1926-1936 shows that in the more recent decade the areas of *BS* and *BW* climates have expanded at the expense of *Cs* in southern California and of *Ds* in the northeastern parts of the State. A frequency diagram on which the climate of each year between 1916 and 1940 at 150 stations is classified shows that only 21% of the stations have remained in the same climatic class since 1916, and that more than 20% have shifted from one class to another after any given interval of three years. Some stations, such as Chico, experience one type of climate for 5 to 7 years, and then change to another type for a period of comparable length. These variations are regional rather than statewide. In every year between 1916 and 1940 both positive and negative departures from normals of both temperature and precipitation were recorded at some stations in California.

Maps of Current Trends in California Orchards and Vineyards. Peveril Meigs, State College, Chico, California.

Abstract: Regional concentration and trends in acreage of California orchards and vineyards can be studied to advantage through a series of maps that represent by counties the total acreage and proportion of non-bearing (youthful) acreage for each variety of fruit and nut. On nineteen types of orchard and vineyard so studied, only two display vigorous expansion at present: almonds and lemons. The acreage of thirteen is shrinking actively, and that of four is approximately stable. Statewide trends in acreage are related primarily to economic factors, prices and profits, rather than to environmental factors. Thus the prices of almonds and lemons have been relatively well maintained during the depression, in the former case because domestic production is still insufficient to meet the requirements of consumption, and in the latter because the growers' association enjoys a near-monopoly.

Of the major fruit districts of the State, the San Francisco Bay area shows the greatest deficiency of new plantings. Prunes, apricots, apples, pears, and cherries, all of which are centered in the Bay district, show decided tendencies toward shrinking.

In order to determine the "neutral point," the percentage of non-bearing trees that is needed to maintain acreage unchanged, a formula may be devised that is based on changes in acreage that have been actually associated with specific proportions of non-bearing acreage.

(This paper has been published in full in *Economic Geography*, 17:275-286, 1941.)

The Site of Early Los Angeles. Ruth E. Baugh, University of California at Los Angeles.

Abstract: Los Angeles, founded in 1781, was one of three civilian settlements planted in Alta California that survived the difficult early years. Its site, shown on two early maps, was well suited to an agricultural pueblo founded to produce grain for presidios. Water supply was the prime requisite for such a colony in an area of light and undependable rainfall.

The site chosen was a broad terrace adjacent to the Los Angeles River where it was feasible to divert water. Hills on the west and a wide arroyo on the east hemmed in the

holdings of the colonists. Argüello's map, sketched in 1786, shows the simple plan of the pueblo: town lots fronting on the plaza, planting fields, the river and the mother ditch. The Ord map of 1849 shows the farm land served by a network of irrigation canals. Grapes have by this time replaced grain as the dominant crop. Residential and business sections still are grouped around the plaza. Lanes follow farm boundaries, and a conventional framework of streets and lots appears south and west of the original core.

Today the parent settlement is still the nucleus of Los Angeles. The location of the Civic Center near the old plaza ties the present to the past. And the Los Angeles River, which determined the choice of the site of the pueblo, still serves the city, contributing an appreciable fraction of the metropolitan water supply.

(This paper has been published in full in *Economic Geography*, 18:87-96, 1942.)

Landscapes of the San Gabriel Mountains. JOSEPH E. WILLIAMS, San Francisco Junior College. Published in full in this issue of the *Yearbook*.

The Occurrence and Use of Black Sand from Beaches and Terraces at Monterey Bay. CHARLES NOBLE BEARD, Fresno State College, Fresno, California.

Abstract: On the eastern shore of Monterey Bay are conspicuous surfaces, sloping seaward, 20 to 250 feet above sea-level, which appear to be terraces of marine origin. They have been carved from soft formations of upper Cenozoic age. Sand dunes, obviously derived from the beach during recent time, cover parts of them. Deposits containing marine shells have not been found on these surfaces, but similar surfaces are found in the vicinity of Santa Cruz to the northwest, at heights of 20 to 100 feet above the sea, which are undoubtedly of marine origin.

Numerous lenses of black sand, that attain a maximum thickness of 6 feet, are found at about 150 to 200 feet above sea-level 4 miles west of Watsonville. This sand has a high percentage of magnetite, and resembles black sand now being deposited on the beach 1 mile to the west. The lenses lie at the base of a steep slope, probably a former sea-cliff. The Coast Reduction Company, Inc., has a plant 6 miles west and slightly north of Watsonville, for handling black sand from the beach. At this plant the magnetite is separated magnetically from the other constituents, and certain other minerals are also recovered. The sand contains gold and silver in minor amounts. An unusual constituent is a thorium-uranium silicate that has not yet been named. This mineral is found both in the beach sands and in the terrace sands 4 miles west of Watsonville, and thus affords strong evidence that the terraces are of marine origin.

Thursday forenoon session, June 19:

Geography in the Junior Colleges. JOHN J. BUONCRISTIANI, Office of the Coördinator of Information, Washington, D. C.

Abstract: This report presented the results of a survey approved in 1940 by the Executive Council of the Association (*cf.* this *Yearbook*, 6:48, 1940). Information was collected by means of a questionnaire sent by the Secretary-Treasurer, Mr. Williams, to all junior colleges in the states on the Pacific coast.

The survey shows that the representation of geography in the junior colleges has not kept pace with the growth of the colleges themselves. Their principal shortcoming in this respect is the lack of trained instructors. Those who give the courses in geography are generally members of departments devoted to other subjects. Of the thirty colleges from which answers were received, only four appeared adequately prepared to offer competent instruction in geography.

(This paper will be published in full in a forthcoming issue of the *Junior College Journal.*)

Wind and Trees. ROBERT W. RICHARDSON, Washington, D. C. Published in full in this issue of the *Yearbook*.

Localization of the Aircraft Industry in the United States. EDWIN H. HAMMOND, University of California, Berkeley. Published in full in this issue of the *Yearbook*.

Melbourne as a Functional Center. CLIFFORD M. ZIERER, University of California at Los Angeles.

Abstract: Situated at the head of Port Philip Bay, Melbourne is at the approximate center of the rich central lowland of Victoria, which extends about 150 miles both to the

east and to the west. Low gaps in the Dividing Range some 35 miles to the north of Melbourne afford easy routes to the productive interior of Australia.

The city occupies an area about the head of Port Philip Bay. Ample land is available for all types of urban use. The commercial and administrative core occupies a well drained tract of land along the Yarra River about two miles north of the head of the Bay, which was selected by the first settlers. Large tracts of poorly drained lowland bordering the lower river are devoted to industries and shipping. Residential suburbs have spread principally toward the east and southeast over an area of varied relief, sedimentary rocks, good soils, and scattered forest. The basalt plains to the north and west have been less attractive for residential use. A series of entrenched valleys interrupts the continuity of the area occupied by the city.

Melbourne is basically a manufacturing and commercial city. Older residential districts bordering the commercial core are steadily being absorbed by increasing numbers of light industries and by the expanding central commercial district. Shoe and textile factories are conspicuous in the decadent inner suburbs. Heavy and offensive industries and such as are especially dependent on transport by rail and water are mostly concentrated on or near the lowlands at the head of the bay. Shipping facilities are concentrated mainly along the lower Yarra River rather than on the bay front. Continual dredging of the channels of the river and bay has been required to maintain direct connection with established warehouses and factories.

(This paper has been published in full in the *Annals of the Association of American Geographers,* 31:251-288, 1941.)

Renewed Expansion along an Old Chinese Colonial Frontier. Joseph E. Spencer, University of California at Los Angeles.

Abstract: There has been a persistent tendency to attribute too much unity to China as a national entity. Both Chinese and foreign scholars have contributed to this tendency by giving their primary attention to events, mainly military and political, that have occurred in northwestern China. They have not given sufficient heed to the gradual encroachment, through the centuries, of the historical "Chinese" upon "barbarians" dwelling in the southern and southwestern parts of the area called "China."

The judgment of the historical "Chinese" concerning membership in their national group was based on cultural traits rather than upon racial or political affiliation. Hence many of the inhabitants of what was politically "China" were looked upon as barbarians by the bearers of official Chinese culture and political power. The Sinification of the inhabitants of much of the Chinese political area has been gradual, proceeding from colonies established by migrants from the old Chinese nuclear land.

It has been at times of invasion and conquest by barbarians from the north that the largest migrations southward and southwestward of the historical Chinese have occurred. Their migrations under the impact of the Japanese since 1937 is thus to an appreciable degree the recurrence of a process that has gone on intermittently through two thousand years. The barbarians of today are able to exert a far more powerful push than any of their predecessors. But in their advance on old and new frontiers the Chinese, too, have the advantage of modern cultural goods. Their own advance is therefore more powerful, their cultural conquest more thorough, and the areas they occupy more extensive than in the past. The present migration will obliterate nearly all the frontier areas that have heretofore escaped Sinification.

Thursday afternoon session, June 19:

The California Mapping Plan. Willis H. Miller, California State Planning Board, Sacramento.

Abstract: Although more than ten million dollars have already been spent by public agencies for mapping, California is today less than half covered by adequate maps. This unsatisfactory situation is largely the consequence of a lack of coördination. Recognizing the need for more and better maps, the California State Planning Board has prepared a program of coöperation of State and Federal agencies for the better mapping of the State. This program is designed to give a statewide coverage of each of nine basic kinds of surveys and maps: control surveys, plane coördinates, aerial photographs, topographic maps, soil maps, vegetation maps, geological maps, geographical (land use) maps, and State and county base maps. When put into effect, this plan will give California the most comprehensive mapping program in the country, and will assure a maximum return for

every dollar spent. The total annual cost to the State will approximate the amount now being spent by public agencies in California.

Symposium, arranged by JOSEPH E. SPENCER, University of California at Los Angeles, and JOSEPH E. WILLIAMS, San Francisco Junior College.

Abstract (by Joseph E. Spencer): The afternoon of June 19 was devoted to an informal forum discussion of agricultural and settlement landscapes of the Occident and Orient. The particular questions discussed were (1), "Is there a field pattern, or a settlement pattern, which can be called exclusively 'Occidental' or 'Oriental'"?; and (2), "How does an 'Occidental' landscape differ from an 'Oriental' one?" After some introductory remarks by Mr. Spencer, Mr. Williams briefly set forth a series of diagnostic features which seem to characterize the "normal" European and American landscape of both urban and agricultural regions. He illustrated field patterns, settlement forms, and road systems by blackboard sketches, and referred to the spread of such features with the spread of European colonization over the world in recent centuries.

Mr. Spencer then proceeded to a similar description of "Oriental" field and settlement forms that may be considered "normal." He pointed out the very wide use of complex terracing developed in the irrigated rice lands of the whole of eastern Asia and the appreciable extension of the terrace technique in recent centuries to non-irrigated field systems. He also pointed out the absence of meadow, pasture, or hay-crop land as a normal field type, noting the role played by terrace boundaries, waste land, and so forth. He used Mr. Williams's own diagrams to describe widely prevalent field patterns and settlement forms which to all practical purposes are identical with European and American patterns, with the exception that in America the areas involved are generally larger.

General discussion among the participants brought forth facts concerning the amount and degree of spread of the "Occidental" forms of developing the landscape over many sections of the earth; but time was lacking in which the wider ramifications of the central question might have been explored.

Mr. Spencer stated a tentative general conclusion somewhat as follows: In field patterns the Orient has everywhere made more use of the terrace than the Occident has, and has made but little use of forms based on fields devoted specifically to hay crops. In general, fields are smaller and the smaller settlements often more tightly packed together than in many parts of the Occident. Within the narrow limits of the discussion there seemed slight chance of isolating definitely "Occidental" or "Oriental" elements of the cultural landscape. Rather, there are traits common to all highly developed cultures which may be used in different degrees for building cultural landscapes superficially very different in appearance. Finally, it would seem that the differences between Occidental and Oriental cultural landscapes are consequences of differences in the cultures themselves rather than of differences in the basic patterns of the landscapes they produce.

Thursday evening, June 19:

Annual dinner, University Club, Pasadena. Address of the retiring President, Frances M. Earle: "Habitation and Environment." Published in full in this issue of the *Yearbook*.

Business Transacted at the 1941 Meeting at Pasadena

The thanks of the membership of the Association were extended to Ruth E. Baugh for the excellent arrangements made for the meeting.

It was voted to hold the eighth annual meeting of the Association in June, 1942, at Salt Lake City, Utah, on the occasion of the twenty-sixth annual meeting of the Pacific Division of the American Association for the Advancement of Science, and Associated Societies. Otis W. Freeman was appointed chairman of local arrangements for the meeting.

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C. M. Zierer, University of California at Los Angeles, Los Angeles, California

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This year's list of members shows more than the usual number of changes of address. Some changes may have been missed. Members will make the work of the Secretary-Treasurer easier if they report to him changes in address that should be made in his files.

THE ASSOCIATION OF PACIFIC COAST GEOGRAPHERS

THE ASSOCIATION of Pacific Coast Geographers was organized on June 27, 1935. The object of the Association, in the words of its Constitution, is "the promotion of scientific research in Geography and the diffusion of the resulting scientific knowledge." Annual meetings are held in June, usually in conjunction with the Pacific Division of the American Association for the Advancement of Science.

Membership is by invitation; and in practice has generally been limited to those having professional training in geography. Student memberships, open only to undergraduate students in geography, carry all privileges except that of voting. Annual dues are two dollars for regular members and one dollar for student members

The Association publishes annually the **Yearbook of the Association of Pacific Coast Geographers.** The **Yearbook** contains the proceedings of the Association, abstracts of papers presented at its annual meetings, and a few papers selected from those presented to be published in full. The price of the **Yearbook** to non-members and libraries is one dollar per copy.

Correspondence should be addressed to the Secretary-Treasurer.